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Journal of the Royal Society of Arts.

No. 3,600. VOL. LXX.

FRIDAY, NOVEMBER 18, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

ONE-HUNDRED-AND-SIXTY-EIGHTH SESSION, 1921-1922.

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER 23rd, at 8 p.m. (Ordinary Meeting); PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., Albert Medallist, "The Coming of Age of Long-Distance Wireless Telegraphy and some of its Scientific Problems" ("Trueman Wood" Lecture). ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

FRIDAY, NOVEMBER 25th, at 4 p.m. (Joint Meeting of Dominions and Colonies and Indian Sections.) A. H. ASHBOLT, Agent-General for Tasmania, "An Imperial Airship Service." BRIG.-GENERAL LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "X-Rays and their Industrial Applications," by MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc., have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W. C. 2.

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

DOMINIONS AND COLONIES SECTION.

The Council have appointed the Hon. Sir Edgar H. Walton, K.C.M.G., High Commissioner for the Union of South Africa; Mr. M. L. Shepherd, Acting High Commissioner for Australia; the Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., and Sir Charles H. T. Metcalfe, Bt., members of the Committee of the Dominions and Colonies Section.

POSTPONEMENT OF PUBLICATION OF CHAIRMAN'S ADDRESS.

Owing to unavoidable delay in preparing the illustrations, it has been found impossible to print the Chairman's Address in this issue of the *Journal*, as was previously announced. It will, however, appear in the next number.

PROCEEDINGS OF THE SOCIETY

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 9TH, 1921

MR. WILLIAM GRAHAM, LL.B., M.P., Member of the Medical Research Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Baillie, Andrew Francis, London.
Bliss, Ernest H, B.Sc., London.
Graham, Andrew MacIntyre, Liverpool.
Greaves, Richard Methuen, Portmadoc.
Leno, Albert James, Uxbridge.
Morris, Squadron Leader A. S., O.B.E., R.A.F.
Rogers, Captain Archibald Clement Campbell, Tringganu, Federated Malay States
Symington, Harry, London

THE CHAIRMAN, in introducing Mr. Wilson, the author of the paper to be read that evening, said the members of the audience would agree that they were fortunate in having the services of Mr. Wilson to lecture on the subject of industrial fatigue. The present time was really one of transition from the economic conditions of war to the economic conditions of peace, or at all events to the early economic conditions of the post-war period. The artificiality which had existed during the war was tending to pass away, and if the industrial conditions in almost any country in Europe were examined at the present time it would be found as a rule that those countries were doing their best to get back to some bedrock cost of production. Serious reductions of wages were everywhere being proposed, and in many cases adopted, sometimes with the substantial agreement of both sides in the industry and occasionally with a good deal of conflict. That was true of practically every European country, but it was, of course, necessary to make some exception—and that was very important in the case of Great Britain—where Germany was concerned. Germany had experienced recently an artificial boom in trade, due to certain currency conditions, the depreciation of the exchange and so forth, which had given her certain advantages in the export of her goods. It was perfectly plain now to everyone who had regard to the prevailing boom in speculation, which was true of Germany, that something approaching a crisis was coming. Many of the best thinkers in this country felt there would be a great reaction from that crisis on the industry and commerce in Great Britain, just at the time when that industry and that commerce were beginning to show some signs of a real revival after the depression of the past eighteen months. He thought everyone present would agree that if this country was to come through such a crisis successfully and if, above all, it was to regain the markets of the world which it had so far lost, its industry must be in every way efficient. Great Britain could not afford to tolerate much longer the undoubted waste that was taking place in a large part of its industrial system. As Mr. Wilson would probably indicate in his paper, the study of what was called in America "scientific management" was only just beginning in this country, and it would be generally agreed also that the investigation of such problems as the influence of temperature in the factories on industrial output, the response in the production of output to improved conditions of work, and a large number of other cognate problems, was also only just being undertaken. Personally, he deplored the recent tendency of the Treasury to reduce the already insufficient financial provision made for that work, and it was perfectly clear that, during the present period of economy, efforts must be made, both in the House of Commons and outside, to convince Members of Parliament that any large withdrawal of public or other funds from such work would prove to be an aggravated form of waste. Funds must be provided to enable the work to be continued, in the hope that the elimination of waste, both human and material, from the industrial system would be brought about, that the markets of the world would be

recovered, and, above all, that greater comfort and a greater contentment in industry would result, and at the same time British remuneration be safeguarded in what was probably the only sound way, namely, by the adoption of scientific methods. The remarks he had made were a very general and very vague introduction to the paper, but he was sure Mr. Wilson would regard them as sufficient for the purpose Mr. Wilson had a very deep and wide experience of the problem on which he was about to address the meeting, and he had the greatest possible pleasure in calling upon him to read his paper

The paper read was:—

THE WORK OF THE INDUSTRIAL FATIGUE RESEARCH BOARD AND ITS APPLICATIONS TO INDUSTRY.*

By D. R. Wilson, M.A., Secretary to the Board.

Introduction.

The present paper touches on an aspect of industry which until quite recently has been almost entirely ignored. Indeed, apart from a few sporadic experiments on the part of individual employers, of which Mather's trial of the 48-hour week in 1894 is in this country the earliest known example (22), no systematic attempt was made to study the human factor in industry in its physiological and psychological bearings until shortly before the war, when Kent conducted an investigation into industrial fatigue at the request of the Home Office (21), and during the war, when many valuable contributions to the knowledge of the relation of hours of work to production, lost time, etc., were made by the Health of Munition Workers' Committee (18, 19).

To study these problems on scientific lines, and in particular to continue the work already carried out by the Health of Munitions Workers' Committee, the Industrial Fatigue Research Board was appointed in July, 1918, by the Medical Research Council and the Department of Scientific and Industrial Research.

In planning their work, the Board decided to approach the subject referred to them from two directions: deductively, by means of investigation of industrial conditions that actually exist or have existed; and inductively, by means of research on fundamental principles. The latter work has recently been transferred to expert committees appointed by the Medical Research Council, and the present paper deals only with the industrial investigations.

These can be divided into two groups, i.e., those concerned with a given industry and those concerned with a given subject (17). The Board have, for instance, completed or in hand extensive investigations into the tinplate, iron and steel, cotton, silk, laundry, boot and shoe and pottery industries. For the supervision of these they have set up special Committees, which representatives of the industries concerned are invited to join. At the same time, the Board have instituted research on special subjects, such as vocational selection and motion study, in individual factories where special facilities were offered.

Up to the present, the human factor in industry has received attention chiefly from two points of view, namely, the health of the worker and his safety, and no one can look back on the last 15 years without being impressed with the enormous advance that has been made in these respects. On the other hand, the physiological and psychological response of the worker to the conditions of his work has been almost entirely neglected, notwithstanding that this response is more sensitive than that of either his health or safety, so much so that the principal difficulty arising in its study lies in unravelling the tangle of the different conditions affecting him and ascribing to each cause its own effect.

One reason for this neglect is natural enough. A subjective phenomenon attracts notice to the extent that it is abnormal. Physiology is the property of the normal man, and physiological changes often remain unobserved and unstudied primarily because they are universal.

An additional reason is probably the fact that both the symptoms and causes of physiological disturbances are less apparent than those of the other factors already mentioned. In the case of industrial disease, the effects for the most part are distinctive, and, although the predisposing causes are often obscure, the direct cause can generally be detected, isolated, and made the subject of special research. Similarly, in regard to safety, not only is an accident an unmistakeable occurrence, but the immediate cause can at once be identified and put right.

These distinctions, however, are not meant to imply that the work on which the Board is engaged is unrelated either to

* The numbers in brackets refer to list of the Reports of the Industrial Fatigue Research Board given at the end of the paper.

industrial medicine or to industrial safety, or that it should be regarded as a subject for isolated study. Unfavourable physiological conditions, if pronounced or long-continued, can readily impinge upon the sphere of pathology by causing disease; similarly, they can bring about a state in the worker which diminishes his immunity from accident. In addition, much of the Board's work is closely related to welfare; the two, in fact, have a common aim, amelioration of the worker's environment, the only difference being that in the one case this is treated from a physiological or psychological, in the other from a sociological aspect. The Board's work, indeed, marches with both industrial medicine and welfare, with rather indefinite boundaries between their respective spheres.

METHODS ADOPTED.

The healthiness of industrial work can be gauged by the absence of disease; its safety by the immunity from accident. What is the test whether or not the conditions are favourable from a physiological aspect? Three possible methods exist. First, unfavourable conditions may bring about the onset of fatigue in such a way that complete recovery at the end of the working period is not assured, with the result that accumulation of fatigue occurs as time goes on. In such a case, the effects of fatigue will probably be reflected in the sickness experienced or in the amount of time lost in the factory, and the physiological conditions of the work can be gauged through a study of these

Secondly, the fatigue experienced may stop short of this point and remain consistent with complete recovery on rest, and therefore with health. Here the above tests are clearly inapplicable, but if a subjective test could be devised giving directly a measure of the fatigue present at any moment, it would be possible by applying it to trace out the effects of the conditions and to study their variations. Unfortunately, in spite of several attempts, no such test has up to the present been discovered, and an indirect method of testing the physiological results of work has had to be used

Thirdly, unfavourable conditions may re-act in such a way as to impair the power of doing work; in other words, the worker is prevented from putting forth his best effort. This effect can be measured by applying some test indicative of his "*fitness*," or, as it is generally termed, his "*working efficiency*."

The word efficiency is now used in so many senses that it is desirable to state at the outset its precise meaning here. Throughout this paper it is not to be taken as equivalent merely to *productive* efficiency, but as the physiological quality resulting from favourable conditions of work, of which increased production is only incidentally a symptom. This distinction is of real importance, as it is quite possible to speed up production for a short period with results that eventually turn out to be harmful.

Five main tests for "fitness" or "efficiency" have been used by the Board, though others have been adopted occasionally to meet special circumstances. These are:—

1. Variation in output.
2. Sickness and mortality.
3. Labour turnover.
4. Lost time.
5. Accident incidence.

1. *Variation in output*, whether over a day, a week, or a longer period, has been the most generally used, and provided that adequate allowance can be made for certain disturbing factors (such as incentive or technical changes), is probably the most trustworthy.

The advantage of this test is that it can be applied either by the collection of current data, i.e., by actual observation of the worker, or by the examination of existing records, and both methods have been adopted by the Board's investigators. There are, however, two limitations to the use of output as a test for fitness.

In the first place, it can only be applied to processes which lend themselves to measurement of output in terms of units, which are either constant over a sufficiently long period or are capable of being converted into a common unit by some simple calculation. Secondly, the sensitiveness of this test depends on the nature of the work, and in particular, on the extent to which the human factor plays a part in production. This varies from 100% in completely manual processes to almost 0% in completely automatic processes (7). For the latter kind of process output is obviously an unsuitable test, and another must be found before the worker's efficiency can be adequately studied.

2. *Sickness and Mortality.* So far as the investigations of the Board extend, they tend to show the fatigue now existing is non-cumulative and is normal rather than pathological. Its relation to health is, therefore, less pronounced than it was at the time when the Board was started. Nevertheless, the Board have paid some attention to this subject for three reasons.

First, physiologically unfavourable conditions, if inherent in a given occupation, may sometimes be reflected in the high rate of sickness and mortality for that occupation, as compared with the industry generally. Secondly, in industries involving exceptionally arduous work or subject to exceptional conditions of employment, the study of morbidity and mortality may suggest whether excessive fatigue, due to such work or conditions, actually exists, and if so, in which particular occupation (5). Thirdly, an abnormally high rate of sickness or mortality found in a given industry may in the absence of other explanation be primâ facie an indication that such industry will offer a fruitful field for investigation.

3. *Labour Turnover.* Just as the bodily health of an industry is reflected in the magnitude of its sickness incidence, so is the "industrial health" of a factory reflected in the variations of certain phenomena, the study of which accordingly has a special practical bearing on fatigue and efficiency.

The first of these is "labour turnover" or the rate of change in the working staff, which may be used (with certain limitations) as a guage or indicator of the internal conditions of a factory. A continuously high rate occurring in one department as compared with the factory generally may, for instance, be due to causes such as fatigue or ill-health produced by the work, unsatisfactory hygienic conditions, or faulty selection of workers for a particular task; an abrupt rise in the rate may indicate the introduction of a piece-rate which is regarded as unjust, or the appointment of an unpopular departmental manager or foreman. Which of the several possible reasons is the determining factor must, of course, be made the matter of special inquiry; estimation of labour turnover in itself can only indicate the need for such inquiry.

Broughton, Newbold and Allen, (13) following methods devised by Greenwood, have calculated the labour turnover in a number of factories, and have given a reliable and sensitive method of estimating it. A characteristic feature of all the tables is the high rate of loss during the early months of service, emphasising the scope for vocational tests to discover the aptitudes of applicants for employment.

4. *Lost Time.* A second test of the "health" of an industrial organisation is the time lost on the part of the workers. Lost time was originally investigated by the Health of Munition Workers' Committee, in the expectation that it would throw light on the prevalence of fatigue during the war. It has been only occasionally used for this purpose by the Board (5), chiefly because it is not a suitable measure of the normal fatigue which for the most part exists to-day.

5. *Accidents.* A clear relation exists between efficiency and accident incidence, since the incurring of any accident involves lessened capacity, even though it may be so trivial as not to cause absence from work. Greenwood and Woods, (4) by the statistical treatment of accident records kept by certain munition factories, have adduced evidence to show that accident incidence is not wholly a matter of chance, but depends largely on some quality of susceptibility inherent in the personality of the victims. The further study of this important question is now under consideration.

In addition to these standard methods, several others have been used by the Board to meet special circumstances.

DIFFICULTIES EXPERIENCED.

A brief and necessarily incomplete description has now been given of the methods hitherto adopted by the Board to measure the fitness or efficiency of the worker, with a view to discovering, not whether his productive capacity is at a maximum, but whether his environment or other conditions of work are physiologically favourable. Before proceeding to an account of the results actually obtained, it may be desirable to mention some of the principal difficulties experienced in our work.

Human efficiency is influenced by a large number of conditions functioning simultaneously. There are, for instance, temperature, humidity, lighting, various technical considerations (such as change of type of work), labour turnover, conditions outside the factory (such as housing, food and transport), at the present time variations

in working hours caused by the abnormal conditions of trade, and finally the individuality of the workers themselves. Theoretically, in order to ascertain the effects of any one condition (such as temperature), it is desirable that that condition alone should vary, all other conditions of work (such as arrangement of hours, product of manufacture, social circumstances of the worker) being constant. In field investigation, however, circumstances, as a rule, cannot be made to order, but must be accepted as they are, and it is very rarely that the above arrangement can be realised even approximately in practice. Usually, therefore, the Board have had to be content with conditions which lend themselves to treatment with approximate truth after the application of certain corrections. It is impossible to go into these fully here, but as examples, works as homogeneous as possible can be selected for comparative study, units of production can sometimes be expressed in terms of a common unit by suitable conversion formulæ, minute data can be collected and those constant in regard to a given variable extracted for special study, mass data can be obtained and assumed to represent average conditions, etc.

A second difficulty has been the uncertainty of how long existing conditions would continue in any research undertaken. In normal times, the hours worked and their arrangement might have been anticipated as being one of the few constants the Board would have to deal with. Since we started work there have been no fewer than three abrupt changes in this respect. Our work was begun at a time when long war hours existed in most industries; then came the Armistice, followed by a general shortening of hours; finally, for more than a year, short or irregular time has been worked in many industries, and conditions have become altogether abnormal.

A third obstacle has been the difficulty in discovering suitable raw material for our work. For instance, there must exist throughout the country a mass of records of different kinds which only require working up in order to throw most valuable light on the problems on which we are engaged. Employers often are naturally unconscious of their value in this respect, and it is generally only by chance that they have been brought to our knowledge.

One difficulty we have *not* experienced has been the obtaining of facilities for research, and it is pleasant to testify to the extent to which we are indebted to the co-operation of both employers and workmen. Employers whom we have approached have, without exception, placed the whole of their information at our disposal, have continually helped us with advice, and in several instances have made experimental alterations in their works in our interests. Workmen, again, when once they have understood the object of our work, have helped us in every possible way, often to the extent of devoting a considerable part of their spare time to our interests.

EXAMPLES OF RESULTS OBTAINED.

The results obtained in the different industrial investigations of the Board may be regarded as falling into three categories, according to whether they relate to:—

(*a*) *Hours of labour*, including spells, rest-pauses, etc.

(*b*) *Other conditions of employment*, or the physical conditions of the workers' environment, constituting the *impersonal* factors in efficiency and fatigue. These include temperature, humidity, ventilation, lighting, dust and vibration.

(*c*) *Methods of work*, constituting the *personal* factors in efficiency and fatigue, such as vocational selection, motion study, seats, machine design, etc.

HOURS OF LABOUR, ETC.

The pioneer work in this country on the relation of hours of work to fatigue was carried out by the Health of Munition Workers' Committee ([18], [19]). The false economy of hours of work above a certain length was then clearly demonstrated by Vernon, who found that the long periods of employment introduced ostensibly to bring about increased production resulted in many processes in such a reduction in hourly output as more than to counterbalance the additional time available for production, so that the total output was actually less than when the hours of work were subsequently reduced.

The work of the Board deals largely with variations in output over a given period.

(*a*) *Variations in Output during the Day.*

A study of variations in output at short intervals such as an hour is of interest for the tracing of typical work curves for different kinds of work, and for indicating the existence of fatigue at the end of the day.

Fig. 1 relates to the hand-charging of blast furnaces on the 8-hour shift system (5). investigations (mostly in reports not yet published), and was found to be representative of engineering work by the American Committee on Industrial Fatigue both for an 8-hour and a 10-hour plant. Probably, therefore, it may be taken to be typical of work over a short period.

The difference between the curves in the two figures is also of interest. Hand

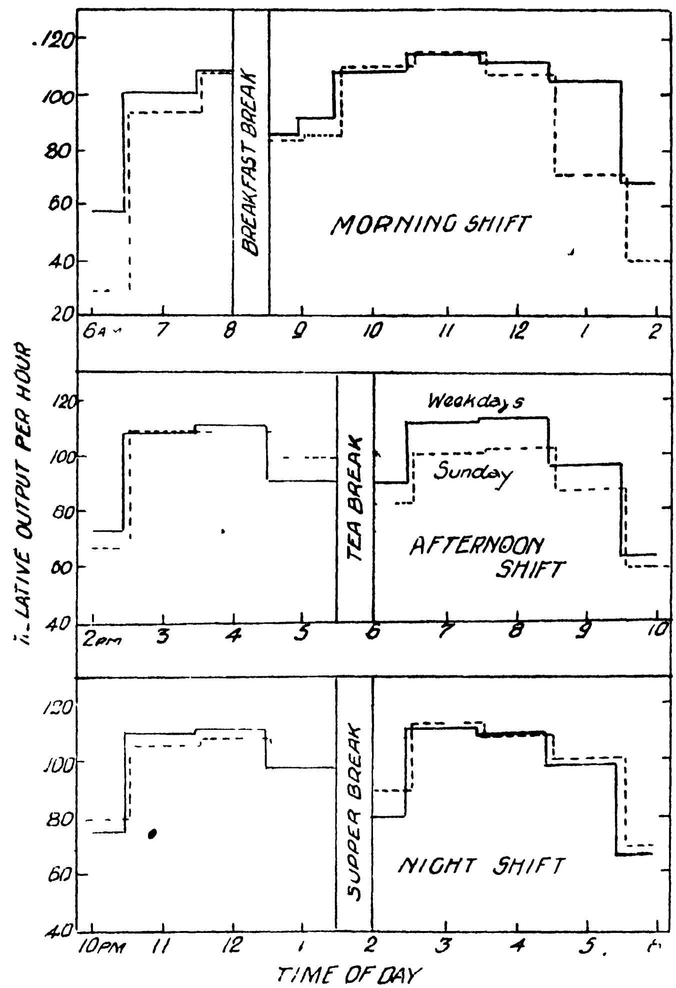

Fig. 1.—Hourly rate of charging blast furnace.

Fig. 2 relates to the weaving of two kinds of silk during a period free from certain disturbing factors (9).

It will be seen that these curves conform to the same general shape. Both show a rise at the beginning of the work-period and a fall at the end, and similar but smaller rises and falls occur with each spell. The same type of curve occurs in many other charging being a completely manual process shows a far greater rise and fall than silk weaving, in which the human factor probably plays a part in production of only about 15 to 20%.

(*b*) *Variations in Output during the Week.*

The variation in daily output throughout the week can be used as a test whether

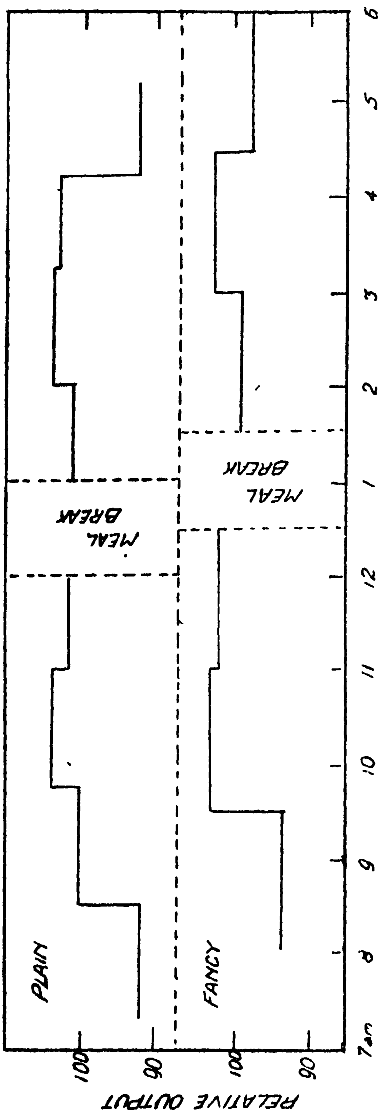

FIG. 2.—Variation in rate of output throughout the day. (Silk weaving)

fatigue is physiological or pathological, in other words, whether there is complete recovery during the night's rest.

Fig. 3 contains sample curves relating to different industries ([9], [10], [5]).

It will be seen that they contain no evidence of cumulative fatigue, since the rate of output shows no *progressive* decline throughout the week.

One interesting point about these curves is that they assume the same general shape as the daily output curves. There is the same rise at the beginning (the so-called Monday effect) and the same fall at the end.

In view of this similarity, it is tempting to suppose that human performance may be dependent on a number of superimposed rhythms corresponding with the periods of work, beginning perhaps with the rhythm of the actual movement and ending with a seasonal rhythm. The suggestion, indeed, has been made that these performance curves are rudimentary approximations to the resultant of various sine-curves, representative of periods of different lengths, just as a stretched string vibrates both in its whole length and in its aliquot parts.

Evidence of the presence of some innate diurnal rhythm in certain kinds of work is afforded from experiments carried out by Muscio on women medical students ([23]). The subjects were divided into two groups (B_1 and B_2), one of which was engaged in continuous academic work whilst the other underwent complete rest. A series of mental tests was applied to each group every hour from 10 a.m. to 5 p.m. on two days, B_1 resting and B_2 working on one day and B_2 resting and B_1 working on the other. The results are given in Fig. 4:

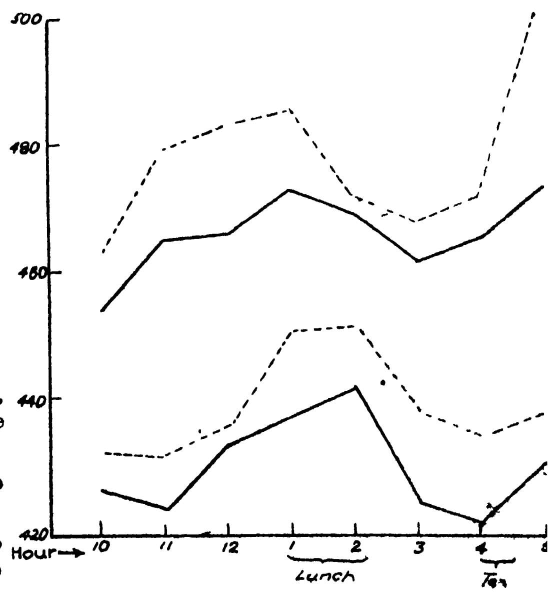

FIG. 4.—The broken lines are the resting groups, the solid lines the working groups. Ordinates indicate group averages. The two upper curves refer to Nov. 7th, the two lower curves to Nov. 6th. (Practice accounts for the fact that the curves for the 7th are above those for the 6th.)

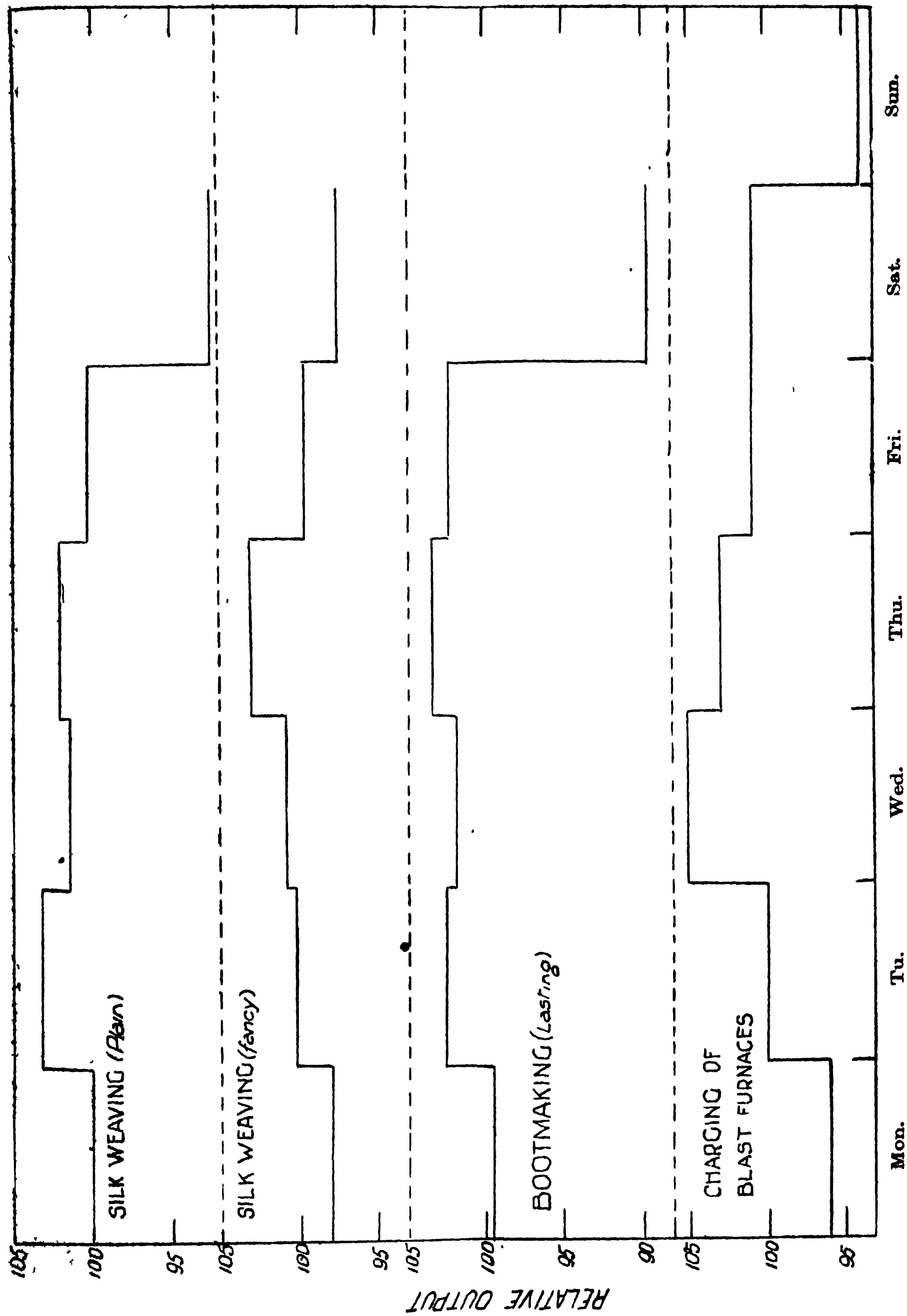

FIG. 3.—Variations in output throughout the week.

It will be seen that the variations in the marks obtained (corresponding with output in industrial work) follow the same course in the resting and working groups, the difference between them being roughly constant. Further, for the greater part of their course all the curves show a marked similarity to the "saddle back" type of curve which seems to be typical of industrial work.

(c) Variations in Output of Longer Periods.

In addition to variations in hourly and daily output, variations over longer periods, such as a week or a month, have been studied in certain industries. These are of special value in enabling us to trace seasonal influences and to compare the effects of different systems of employment.

Seasonal Variations. -Vernon has shown that in heavy work, especially when it in-

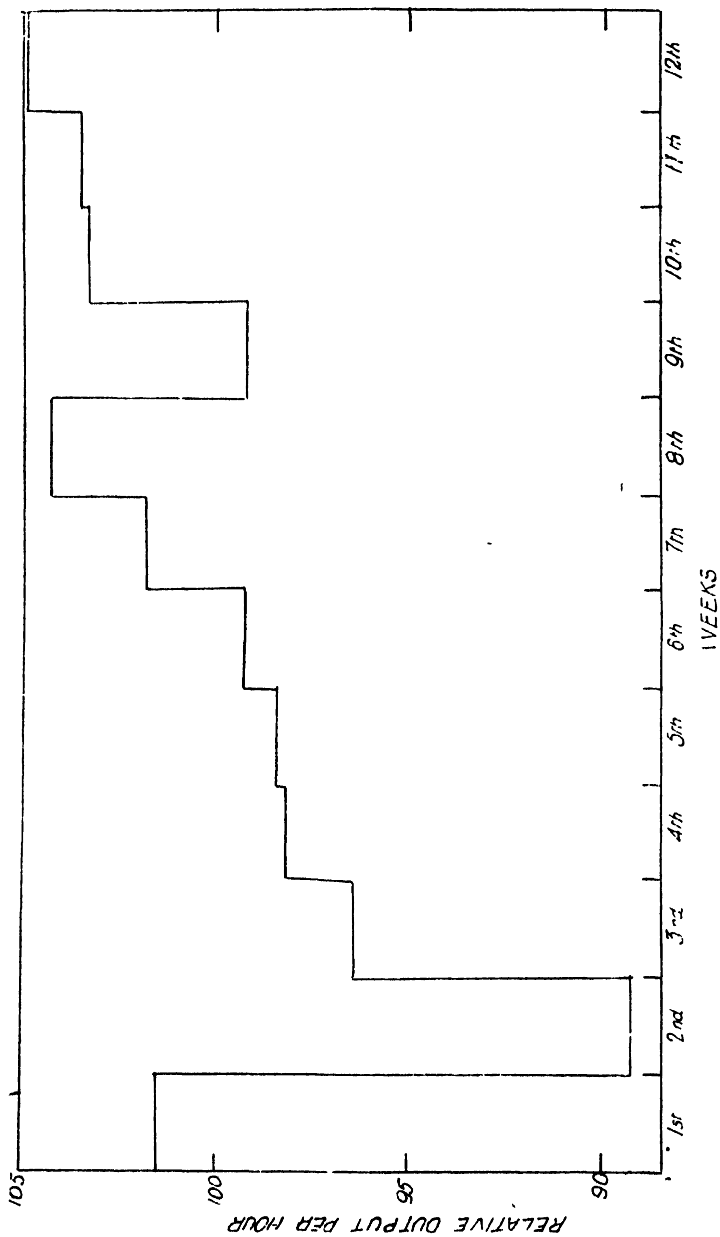

Fig. 5.—Variations in rate of output over a period of 12 weeks from Dec. 15th to Mar. 6th (Silk weaving).

volves exposure to high temperatures, output undergoes a consistent seasonal variation, being, with very few exceptions, greater in winter than in summer. The data collected by him [1, 5] are summarised in the following table :—

TABLE I.—*Seasonal Changes of Output.*

Occupation.	Relative Output during		
	Winter.	Spring and Autumn.	Summer.
Men charging blast-furnaces	105.0	106.5	88.5
Open hearth steel melters	107.7	102.0	96.2
,, ,,	85.7	85.1	84.8
,, ,,	102.5	100.5	97.2
,, ,,	102.5	104.6	102.8
Rolling mill men	107.0	106.5	107.0
,, ,,	124.0	118.0	111.0
,, ,,	105.2	98.4	96.5
Men puddling iron	104.7	102.2	96.0
Tinplate mill-men	103.3	99.9	96.9
Mean temperature at Greenwich	40.0°	48.5°	60.2°

These figures show that with few exceptions the lowest output occurs in summer and the highest in winter, with intermediate values for the spring and autumn.

The variation in the opposite direction was clearly traceable in the process of silk-weaving [9], as is shown in Fig. 5.

Except for the abnormal Christmas week and the week preceding Christmas, there is a practically continuous increase throughout the period. As will be seen later, this effect is to be ascribed largely to the gradual reduction in the use of artificial light.

Effects of Different Systems of Employment.—As an illustration, the effect on output of a reduction in hours in steel-making may be quoted. Fig. 6 gives the output of 10 steel furnaces over a period of four years [6] :

In June, 1912, the men went on to 8-hour shifts, and for the first two months there was no definite improvement in output. It then increased rather irregularly until July, 1913, or 13 months after the change had been made, when it again fell away considerably for some unexplained reason. If the dotted line (representing a rough average) be taken as a criterion, the reduction of hours was followed by an increase in output of about 18 per cent.

CONDITIONS OF EMPLOYMENT, OTHER THAN HOURS OF LABOUR, ETC.

In the Board's investigations some information has been gained as to the relation between the worker's environment and his efficiency, especially in regard to temperature, humidity, ventilation, and lighting.

Temperature.

One illustration of the effect of temperature on output has been already illustrated by the seasonal variations which occur in

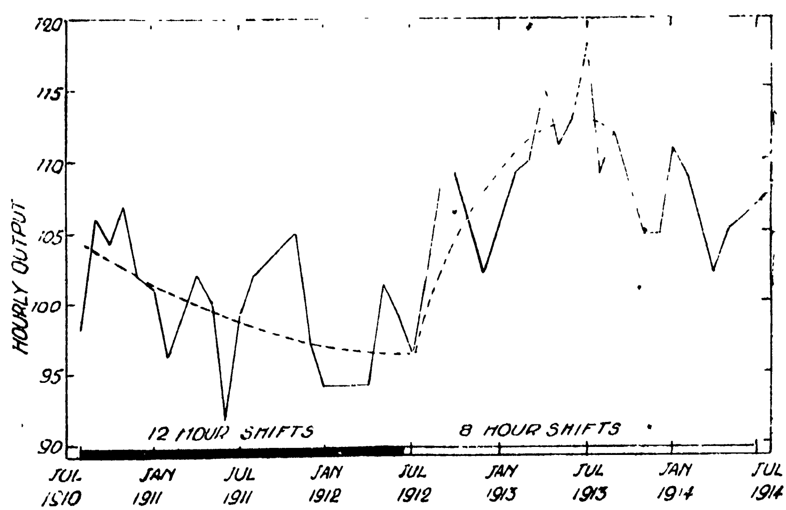

FIG 6.—Output from steel furnaces.

the case of hot and heavy work (*see* Table I.).

Vernon has also adduced evidence to show that in tinplate manufacture the rate of output is greatly influenced by the temperature of the environment, and estimates that in one factory the output of the shifts during the hottest weather was as much as 30 per cent less than during the coldest weather (1).

Humidity.

Vernon has shown that in tinplate manufacture the efficiency of the worker seems to be related to the air humidity, being greater when the relative humidity of the air is low (1).

Ventilation.

In considering the effect of ventilation on efficiency and fatigue, the particular aspect concerned must be clearly defined. The change of air in the environment (if we may so define ventilation) may be regarded from different points of view in respect of its effects on the workers. Pathologically, it may be considered as a vehicle for the removal of dust or of the germs of infection, physiologically as a stimulus to muscular activity, and psychologically as a means of reproducing to some extent the invigorating conditions of outside air. The work hitherto carried out by the Board is concerned with the second of these effects, and in particular the cooling power of moving air.

Some striking results in this respect were obtained by Vernon in the tinplate industry (1). Some of the rolling mills were provided with artificial means of ventilation, such as paddles or air douches, whilst others simply depended upon natural means. The difference in the seasonal variations in output (see above) between the two kinds of mill is clearly shown in the following table :—

TABLE II.—*Comparison of Output in Summer and Winter (Tinplate Manufacture).*

Factory.	State of Artificial Ventilation.	Mean Output in		% Reduction in Summer.
		Dec. & January	July & August	
A.	Good.	100.5	97.5	3.0
B.	Moderately good.	102.5	97.0	6.4
C.	Moderate.	105.5	94.5	10.4
D.	None (good natural).	104.5	93.0	11.0
E.	None (poor natural).	108.0	93.5	13.4

The effect of the good ventilation is clearly reflected in the evenness of output in Factories A. and B. compared with Factories D. and E.

The extent to which atmospheric conditions vary in their physiological effects has been explored by Hambly and Bedford (11) in a number of boot factories by means of the kata-thermometer, an instrument designed by Leonard Hill (20), to measure the cooling power of the air, and similar observations have now been collected in the cotton weaving, laundry and pottery industries. The correlation of the conditions observed with fatigue and efficiency is, however, not yet complete.

Lighting.

The effects of lighting on production have been studied by Elton in silk-weaving, a fine process specially susceptible to variations in illumination. Table III. shows the distribution of output (corrected for certain variables) from 56 looms during the week ended December 20th, 1919 :—

TABLE III.—*Distribution of Output through the Day in Winter (Silk-weaving).*

Period (a.m.)	Hourly output.	Period (p.m.)	Hourly output.
7.30 - 8.30	45.8	1 - 2	47.5
8.30 - 9.45	49.3	2 - 3.15	52.1
9.45 - 11	52.1	3.15 - 4.15	50.9
11 - 12	48.3	4.15 - 5.15	41.9

The use of artificial light was confined to the first and last periods, and to this must be attributed in great part the heavy drop in output observed, since at a later season when artificial light was no longer used, the reduction in output at the beginning and end of the period of employment, though still present, was much less marked. Elton concludes that under artificial illumination production falls, even if electric light of sufficient intensity is provided, and that the magnitude of this fall is of the order of 10 per cent. of the daylight value of the rate of output.

METHODS OF WORK.

The results hitherto described have been based almost wholly on mass data; that is to say, inferences have been drawn on the assumption that with a sufficient number of observations chance irregularities such

as those due to the personality of a particular worker will tend to cancel one another and that the results will in fact represent actuality. There is, however, one important section of the Board's work where this method of procedure is impracticable at present. The *method* of doing work is so much a personal characteristic that any progress in this respect can only be expected from an intensive study of individuals

The part played by the worker himself has no doubt as important a bearing on his efficiency and fatigue as the impersonal factors already dealt with This has, in fact, already long been realised in the United States, where Taylor, Gilbreth and others have raised the study of the personal factor in industry to the level of a definite science In this country little has yet been accomplished on these lines, though a proof that interest in the subject is awakening is shown in the formation of the National Institute of Industrial Psychology, a self supporting organisation formed to study and give practical effect to these principles

It is important that the attitude of the Board towards this side of their work should be clearly defined Briefly it may be expressed by saying that the methods of work have been studied with the primary object, not of securing increased production, but of increasing the *ease* with which a given task can be carried out, first by ensuring that the conditions under which the worker works place no unnecessary obstacles in his way, and secondly, through the proper development of the latent capacities possessed by the worker himself

The former of these stages includes such questions as the relation of machine design to human requirements, and the type of seats and benches provided for the work Wyatt, (8) for instance, shows that certain types of winding frames in the cotton industry involve less stretching and bending on the part of the operative than others

The second stage, namely, the development of the capacity of the worker can be treated from two points of view First vocational selection can be applied, and in this way a worker may be deterred from undertaking a task which is naturally uncongenial to him, and may be transferred with little waste of time to one in which his natural aptitude can be utilised Secondly, means can be taken by the introduction of time and motion study to ensure that the completion of the task is carried on with the minimum expenditure of effort Vocational selection, therefore, may be regarded as an antecedent to employment, motion study as a suitable method of training after employment has been accepted For these reasons the Board have regarded both vocational selection and motion study as within their scope, and as a first step have decided to publish reports containing summaries of the work hitherto done in both subjects (12, 14)

It is impossible in the present paper to enter fully into this side of the Board's work, interesting as it is, since most of the reports dealing with it are still in the press,* but at an early stage of their existence the Board were brought into touch with one factory in which a very complete system of motion study had been in force (an iron foundry) for some years As a result of this system both the output and the earnings of the men (in spite of a reduction in hours) rose enormously

Since this report was issued two investigations (11, 15) based on motion study methods (in a confectionery factory and in a metal polishing factory respectively) have been carried out by Farmer, and these also indicate the vast possibilities of such methods if properly applied in increasing human efficiency in industry

Similarly, considerable research has been carried out on vocational guidance, and a report containing three studies on the question (one an investigation of the "capacities required by the hand compositor in printing, the others inquiries into certain physical characteristics in relation to selection) will shortly be published (16).

THE FUTURE

The policy of the Board hitherto has been to devote the greater part of their resources to the general study of certain industries, in other words, they have concentrated on the industry rather than on a given subject for investigation They have done this with a twofold object first in order to instruct themselves and to extract from an industry as much knowledge as possible bearing on general principles, and secondly to make a beginning in the development of the study of the human factor and in the practical application to industry of the results of research

* A few of the principal results obtained were illustrated at the lecture by means of lantern slides

The field of work, however, is a very large one and little real expansion can be expected so long as its study is left entirely in the hands of a central body with limited funds, whose activities have been recently seriously curtailed owing to the need for national economy. Real progress can only be made if industries themselves will agree either to co-operate with the Board or to undertake similar work on their own responsibility.

Obviously, the Board, with their small staff of investigators, cannot do more in any one industry than indicate by means of preliminary work the lines on which research can be profitably continued, and the time has now arrived when, if work of this kind is to be firmly established, industries themselves must participate in it by assuming part of the responsibility for the supervision and the financing of the work.

Co-operation of this kind would have a double advantage. In the first place, it would ensure adequate and informed criticism of our work, and that industry itself would be the judge of its results and benefits. Secondly, it would tend to eliminate one cause of criticism alleged against us, which I am bound to say has undoubted substance, namely, that in our work the technical and mechanical factors have not always been given their due weight. Our work already requires many qualifications, and our investigators obviously cannot as well be technical experts in every trade they investigate. We have tried to overcome this difficulty by inviting the assistance of representatives of the trades concerned to criticise our reports before publication, but in spite of the invaluable help given us, this is not the same thing as having a technical man to take part in the actual work of investigation.

How can these difficulties be remedied? I suggest that Associations for research on the human side should be formed, similar in some respects to existing Research Associations, but with two important differences. In the first place, I regard it as essential for the success of such work that the responsibility for initiation and supervision should be shared equally between the employers and the workmen, acting together. The associations in question, therefore, should be joint bodies, composed of employers and representatives of the workers, with an elected chairman. Secondly, each association, instead of being confined to a single industry, might with advantage be constituted so as to be representative of a group of allied trades. In technical and material research, the questions dealt with affect as a rule only one particular trade. In research of the kind on which the Board is engaged, most of the problems have a more extensive application, and a wider unit of grouping can be adopted. In the textile trades, for instance, most of the processes have a family likeness and differ in detail rather than principle, so that many of the problems arising are of common interest to all the trades. Economy, therefore, as well as greater opportunities, would be secured by combining the whole of the textile trades into a single group, and forming the association from representatives of all the component industries.

Subject to these conditions, there are many alternative courses open. The association might, for instance, be formed entirely of members of the trades concerned, and conduct their own investigations with any help they desire from the Board, or they might be constituted of members of the trades, plus members or nominees of the Board, which is the method we have hitherto adopted. Again, they might engage their own staff for exclusive work for the trades, or they might engage merely the subordinate workers, responsible for the collection of data, calling on a senior investigator of the Board to direct the lines of research. These are matters of detail compared with the general principle that for real and lasting success the supervision of research of this kind in its practical aspect should be in the hands of an association composed predominantly of industrial representatives.

Research of this kind is not expensive, as it involves practically no capital outlay in the way of laboratories or expensive plant, and almost the whole of the cost would be the salaries and expenses of the investigators.

Practical Bearing of the Work.

In research work of this kind there is necessarily a stage during which progress is slow, and some time must still elapse before the full results of the Board's work can be translated into practice. The Board, indeed, have hitherto refrained from starting research solely with the object of arriving at *immediate* practical results; they have instead preferred to study the more funda-

mental issues in the expectation that any practical applications hereafter made may be on sure ground. Nevertheless, it is, perhaps, desirable to meet the possible contention that most of the results so far obtained have merely a theoretical interest, and that industries themselves should not take part in the work until its practical possibilities are more clearly seen.

First, I claim that the work of the Board is the first systematic attempt to ascertain *facts*, which can be used for defining numerically the most favourable conditions of work. The restrictions on hours of employment in successive Factory Acts have been largely the result of compromise between many opposing opinions, and no scientific evidence is even now available to indicate the best arrangement of hours of work of different types. Here alone is a large and most valuable field of work still to be explored.

Secondly, I claim that the work of the Board has a direct and important bearing on increase of production, an increase to be brought about not by any artificial incentive or by appeals to the workers, but by increasing the *ease* with which work can be carried out through obedience to the natural laws of human effort. To take only one example; it has already been shown that the daily and weekly output curves conform to a certain type, which may, perhaps, be the embodiment of some law of rhythm. Is it not possible, by comparing the output curves for the same work done under different arrangements of hours, to determine which particular arrangement indicates the most favourable response on the part of the worker?

Thirdly, I claim that even after the short time the Board has been in existence, many matters have in fact been discovered deserving of immediate attention on the part of the trades concerned. It is impossible to go more fully into this question here, as the points referred to have generally an interest for one special industry, but almost every one of the Board's published reports contains practical suggestions based on actual observation, which could be usefully considered by an industry with a view to immediate application.

Finally, my experience has convinced me that the work of the Board, so far as it has advanced, has had an indirect effect which is, perhaps, not less important than its contributions to knowledge. As already stated, in each of our industrial investigations we have received the help of employers and workmen nominated by the trade concerned. They have met on new and common ground, and it has been very striking to notice the mutual goodwill and the real interest taken in our work throughout by both alike. One reason for this, I suggest, is that industrial life is being viewed from a special angle, whereby employers and workmen get a new insight into one another's difficulties. For this reason alone, the continuance and expansion of the work that we have begun would, I am convinced, be of great value.

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(3) No. 3. A study of improved methods in an iron foundry, by C. S. Myers, M.D., Sc.D., F.R.S.

(4) No. 4. The incidence of industrial accidents with special reference to multiple accidents, by Major M. Greenwood and Hilda M. Woods.

(5) No. 5. Fatigue and efficiency in the iron and steel industry, by H. M. Vernon, M.D.

(6) No. 6. The speed of adaptation of output to altered hours of work, by H. M. Vernon, M.D.

(7) No. 7. Individual differences in output in the cotton industry, by S. Wyatt, M.Sc., M.Ed.

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(9) No. 9. A study of output in silk weaving during the winter months, by P. M. Elton, M.Sc.

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DISCUSSION.

MR. ARTHUR PUGH (Secretary, Iron and Steel Trades Confederation) said he was sure everyone present had listened to the paper with very great interest and had derived much information from the slides which the author had shown. Personally, he was particularly interested in the subject, because the Industrial Fatigue Research Board had done a considerable amount of work in connection with the iron and steel trades. The members of those trades felt very grateful to the Board for the services it had rendered them by the publication of the excellent reports of Dr. Vernon in regard to the effect of industrial fatigue on output in the iron and steel trades, and they were most anxious that the work of the Board should be continued, because they knew from practical experience how much the particular matters which had the attention of the Board entered into the everyday life of the workers in those trades, which were generally arduous trades. If the knowledge which the Board had acquired and the experience of those connected with the Board could be conveyed to those engaged in the iron and steel industry, he was sure it would have good results not only for the workmen but for the industry as a whole and all concerned in it. Those who were engaged in the workshops knew how greatly the little things which affected the workman in his employment entered not only into the question of production but also into the question of the contentment of the workman, and they also knew the psychological effect which the little inconveniences existing in the factory or workshop had upon the workman. Those matters had a considerable effect upon output and upon the whole success or otherwise of the undertaking. It was surprising how little those matters were noticed, and it was only when one had actual workshop experience that one understood how important it was that the conditions of the workshop and the psychology of the workman himself should be studied, and that everything should be done to make the conditions of the workshop as satisfactory as possible. He was particularly struck in visiting a tinplate works one day, in connection with some proposals that his Confederation were submitting for the consideration of the Industrial Council, to notice the number of little things that had contributed very much to the comfort of the workshop, such as devices to prevent unnecessary lifting and to reduce the heat of the furnace. The mills to which he was referring had been operated by the double roll system, in order to find employment for old men, who had left the trade, when the younger men were serving in the Army. The same conditions and the same method of working were continued in the mill after the war was over and the young men returned. The result was an astonishing increase of output, which was attributed almost entirely to those little improvements. Practical experience of the workshop showed that much might be done in that way. In iron and steel works there were often found impure air and unsatisfactory ventilation. It was astonishing to find the difference in comfort produced by working in a shop with a high roof as against working in one with a low roof. The temperature of the workshop affected the men's tempers very often, and the general contentment of the men reflected itself in their output. He was perfectly certain there was a very great field for the work of the Board. When the Board was established those interested in the subject looked forward to great progress being made, and thought: "Here is the Government, as representing the community, really interesting itself in industrial conditions. It is going to employ men with

scientific knowledge, men who have studied various scientific questions, and that knowledge is going to be applied in order to see that it shall not be said in the future that we are a C3 nation.'' He was sure that so far as the Trade Unions were concerned they thought a great deal would be done. Everyone concerned was very much disconcerted when it was announced that on the ground of economy the Board's work was to be restricted, but he agreed with the author that the industries should do a great deal in the matter themselves. He felt su e that, if the Board continued its work and an endeavour was made to bring to the attention of the organised employers and the organised workers the immense advantages which would accrue from the development of the work and their co-operation, the work could be developed to the general advantage—to the advantage of industry, the advantage of the workers, and the advantage of the community. He sincerely hoped that at least the work would not be further reduced and that it would receive Government support, but most of all he hoped that the industries themselves would take the matter up He was certain that, so far as the iron and steel trades were concerned, having regard to the excellent work the Board had already done for them, anything they could do to extend its operations and to give it support would be willingly done.

Dr. D. A. Coles (Medical Officer to the Gas Light and Coke Company), after congratulating the author on his excellent paper, asked if any record had been made as to the difference of output between those who were employed on piece work and those who were employed on time work, and also whether any record had been made with regard to the output of those who were co-partners, those who were ordinary workers, and those who were merely casual workers.

Mr. Wilson said the Board had not specifically dealt with the particular points that Dr. Coles had raised. They had to take the opportunities as they occurred, and they had now only limited facilities for work, a reduced staff and so forth. If the present staff of the Board could be multiplied by ten, there would be plenty of work for them to do. He was very grateful for Dr. Coles' suggestions and would bear them in mind. With regard to the results he had shown, many were not yet published, but most of them were contained in Reports which were now in the press and would appear in the course of the next few weeks. The titles of the Reports would be included in the list of references that would appear at the end of his paper when it was published.

Miss K. Maclean, speaking as a representative of a women's industry, laundry work, said the people she knew in that industry very much appreciated the careful investigation that had been made amongst them. She had worked on a board alongside her women for the past eighteen years, and she could say from experience that the work entailed extreme fatigue, whilst the hours of work were very long. Any suggestions for improving the conditions that might be contained in the Report with regard to the laundry trade, which she hoped would soon be published, would be very much appreciated by the trade. The laundry trade was about to form a Research Society for the investigation of all kinds of technicalities and she thought it would prove of great advantage if something could be done to bring before the notice of the employers in that trade the details which the author had given in his paper.

Mr. Pugh asked if any attempts had been made to invite the co-operation and support of employers generally throughout industry in connection with the work of the Board.

Mr. Wilson, in reply, said the method he advised the Board to adopt was to conduct some initial research in a certain industry and then to approach the employers and the Trade Unions in that industry and ask them to co-operate with the Board. Personally, he thought there was not yet sufficient knowledge of the work of the Board for any general appeal to be made to the whole of the industry of the country with any prospect of success

Mr. Pugh said considerable interest had been awakened in the subject by experiences during the war, and that interest might become less and less if it was not maintained by the Board In order to do that, should not the Board get into touch with employers' organisations, Trade Unions, and so forth? The present might perhaps be a somewhat critical time for the Board itself.

Mr. Wilson said he was now actually in negotiation with several industries on the subject.

Mr. J. Herbert Parsons, C.B.E., F.R.S., asked if the matter was not largely a question of publicity. He thought one of the greatest advantages of the paper was that it had been read before the Society and that it emphasised the valuable work which the Industrial Fatigue Research Board had performed, and it ought to have greater publicity even than that which would be effected by its publication in the Proceedings of the Society. It would be of benefit if abstracts were published elsewhere, so that the work of the Board would become better

known. As one who had nothing whatever to do with industry but something to do with science and a certain amount to do with some of the Committees which were appointed for various specific purposes, it seemed to him that the Industrial Fatigue Research Board deserved support on a much wider basis than the immediate work which it did. It was an object lesson in the combination of scientific work and the utilitarian aspects of scientific work, and he thought that was a lesson not only to the industries, which were frequently accused of not adopting scientific methods, but also to the pure scientists, who were liable to work on such purely scientific lines that they did not appeal to the practical people. It was to the detriment of the purely scientific workers themselves not to be brought into close contact with the actual workers. It was an old established theory, which had received the support of the greatest scientists, that the results of the most practical utility were derived from work which was not necessarily directed to a utilitarian end. There was no question that that was true, but there was reason to think that it had been emphasised rather too much During the war utility was to the fore. Scientific workers were brought into the factories and a great many of them found themselves very much at sea, but it did them a tremendous amount of good to be brought into direct contact with practical utilitarian questions, and they rose to the occasion extremely well For those reasons it was advisable that the Industrial Fatigue Research Board should be advertised as an object lesson Those who were dealing with purely scientific matters were not surprised to find that one of the first economies effected by the Government was the cutting out of the absurdly small amount of money that the work of the Board required That surely was attributable to the fact that, generally speaking, the politician's education had been neglected from the point of view of scientific matters In saying that he was speaking quite seriously, and he thought many politicians themselves would admit it If the Industrial Fatigue Research Board was thoroughly well supported and did valuable work and tended to produce greater amenability amongst the workmen and the industrial employers themselves and had beneficial results, it would be a very valuable means of educating the politicians

PROF. E L. COLLIS, M D, speaking as one who had been interested in the subject of industrial fatigue research from its very inception, said he wished to thank the author for the way he had presented that evening a great volume of work. After listening to the results he had presented, it was difficult to realise that it was only in 1916 that the Health of Munition Workers Committee issued its first Memorandum, in which it summarised the thoughts that were in the minds of those who had interested themselves in the subject of industrial efficiency and fatigue. It was only after the issue of that Memorandum that an attempt was made to ascertain facts, so that there might be something on which to advise the Ministry of Munitions how it should handle the labour upon which the fighting forces then entirely depended for the output of munitions Since that time, 1916, there had been many vicissitudes. The work of the Health of Munition Workers Committee came to an end, an interregnum occurred, and then the Industrial Fatigue Research Board was appointed and carried on its work with some of the results which the author had portrayed. The Board had had many vicissitudes, many changes and many struggles—such as Mr. Parsons had touched on—to maintain its existence, and yet it had achieved the results of which the author had spoken that evening. Those results were due in a great measure to the author himself, who had in his paper belittled his own services in paving the way and smoothing down difficulties so that the observations could be made and the data and records accumulated. In thanking the author for his account of the work of the Board, he wished also to thank him personally for the great work he had done. It had already been pointed out that the so-called economy of the Government had limited the activities of the Industrial Fatigue Research Board Any single one of the investigations the Board carried out would probably increase the efficiency of the workers in British industries to a sufficient extent to return to the Chancellor of the Exchequer more than the whole expenses of the Board in a year He hoped if there were any people present who could make their voices heard in the deliberations of the Empire they would see to it that such a form of economy was not adopted He had been particularly struck by one point in the paper, namely, that the whole endeavour of the Board had been to see what could be done to ameliorate the conditions of the worker; that had really been the fundamental aspect of the work. Except during the immediate stress of the war, the endeavour had not been to increase output, but he could not recall a single instance in which improved conditions for the worker did not immediately result in economy; in other words, where the health and contentment of the worker were attended to, output and profits increased, and the neglect of the former necessitated to a great degree the decrease of the latter. An aspect of the subject which was well worth careful consideration was how far profits came to those whose ultimate object was profits, when they attended to that which had previously been thought to be a purely humanitarian aspect of labour. There was an old saying ascribed to an employer at the end of the eighteenth century, namely, that he gave his money to his employees and God gave it

in shovelfuls back to him That aspect of the work of the Industrial Fatigue Research Board was an appeal to hard sound facts, and if it was grasped, as a result of what the author had said that evening, he thought it would be evident to everyone that the work of the Board must go on and must not be allowed to cease.

Miss E B. Voysey (Welfare Workers' Institute) said she wished to support what Dr Collis had said and to say how much welfare workers appreciated the work of the Industrial Fatigue Research Board It gave them ballast, so to speak. She was very often accused of being "up in the clouds" and having exaggerated notions about the value of welfare work, and she wished her critics had been present that evening, for they would then have realised that far from being visionaries, welfare workers had their feet resting on very solid facts and could claim that welfare provisions were very good business People who urged the adoption of such provisions were often met with the remark · "Oh, but business is business" Generally those who said that meant that they were not going to have welfare work in their factories She had recently been talking on the subject to a very obdurate employer, who said: "But you are away up in the clouds while we are digging down for profits." She had replied that he would not need to dig for profits if he took up the question of welfare work, because then the profits would flow in to him, and she wished he could have been present that evening to hear Mr Wilson's paper She was particularly glad to hear the author say that he thought one of the greatest benefits of the work of the Board had been that it drew together employers and employed, made them understand the problems which confronted them both, and made them realise that their ultimate interests were identical, namely, the success of the undertaking. That was a fact which could not be emphasised too much A great deal was heard nowadays about the need for co-operation, but it was important to go inside the factory and show what co-operation could mean in the very practical manner adopted by the Board When that was done she thought much better results would be achieved In conclusion, she wished to thank Mr Wilson and the Board in general for all they had done for the workers.

The Chairman, in proposing that a hearty vote of thanks be accorded to Mr. Wilson for his paper, said he was very grateful to those who had spoken in appreciation of the paper, because it made his duty in conclusion very light and simple. There was only one point he would like to take the opportunity of emphasising. With reference to Mr. Pugh's remarks, it seemed to him personally that at the present time it would not be possible to do much good by making a kind of general appeal to industry at large. With the limited funds at the disposal of the Board that course of action would be difficult, and he thought the activities of the Board for some time to come must be along the line of appealing to industry by industry, securing, as the author had indicated, the co-operation of the important industries in particular, and extending the work in that way until it was found that a fairly wide field had been covered and that the Board had something to offer the public in the way of substantial results. With reference to the question of publicity, he was strongly of opinion that the work of the Board should be made very widely known. Mr Parsons had referred to the characteristic ignorance of politicians with regard to such work. He certainly pleaded guilty at once to the indictment and almost pleaded guilty on behalf of the House as well, without injustice to his fellow Members of the House of Commons, because, when any economy campaign began, it seemed to make a bee line for the things which were most important in the welfare of the country and ignored other things which might quite well be done without. The remedy lay with the electorate of Great Britain They were the cause, and the Members of the House of Commons were the more or less melancholy result! He wanted to emphasise the duty of the electorate as strongly as he could, because he believed it to be very important indeed Personally he had not had a very long experience of the work of the Industrial Fatigue Research Board, but he could say that Mr Wilson had devoted a very great deal of time and energy to its progress Those interested in the subject were very greatly indebted to him, particularly on the present occasion, because he had undertaken one form of the publicity enterprise in which they must all engage.

The resolution of thanks was carried unanimously

Mr D R Wilson, in reply, said he hoped the vote of thanks had not been given under any misapprehension, because, as he had explained, he could not personally claim any credit for any of the results he had shown All that had been accomplished had been due to the energy and ability with which the staff of investigators employed by the Board had carried out their work, of which he could not speak too highly He wished he had had time to explain the difficulties that had been experienced, not simply the financial difficulties but the difficulties of the actual investigations, as described in his written paper He thought, however, that the audience would agree that the results he had shown on the screen reflected the greatest possible credit on the people who were actually responsible for them.

In reply to Mr. Parsons' remarks about

publicity, there was now in draft a full analysis of the work which the Board had carried out, which would probably be published in a few weeks and could be obtained from the Stationery Office in the ordinary way. That analysis would, of course, be very much more complete than the outline he had given that evening. He hoped every member of the audience who was interested in the subject would buy a copy. Certain reports of which he had given an outline in his paper, such as those on motion study and three or four others, would also be published shortly, and would, in fact, have been published nearly six months ago had it not been for the disorganisation in the work of the Board that had occurred at the beginning of the year. He hoped that when the full results of its past work were published it would be felt that the Board had thoroughly justified its existence.

The meeting then terminated.

NOTES ON BOOKS.

Reports on the Progress of Applied Chemistry, issued by the Society of Chemical Industry, Vol V, 1920 Octavo, 625 pages. London: At the Office of the Society, Central House, Finsbury Square. Price 8s 3d to members; 15s. to non-members.

Perhaps the most difficult aspect of technical writing is the making of satisfactory abstracts of progress Care will enable a writer to avoid any superfluous words, but the real and fundamental difficulty of the abstractor is to maintain a just balance of the relative importance of things so as to avoid too much use of subjects incidental to his own surroundings, companionships, and facilities or tastes in reading.

We must congratulate the editor, Mr T. F. Burton, on the abstracts and treatment, although in a few cases somewhat more rigid editorial control might have been exercised with advantage.

Seeking for a typical example of thoroughness and usefulness as an illustration to our readers of the real value of this epitome of progress, we selected the electrolytic zinc industry. Electrolytic zinc is virtually a new industrial metal, as it is free from the particles of more electro-negative metals which, in the case of ordinary zinc, set up electric strain, leading to corrosion. Hence pure electrolytic zinc does not dissolve like ordinary zinc in dilute sulphuric acid; indeed, it is scarcely acted upon by pure hydrochloric acid or pure sulphuric acid, whether strong or weak. The new zinc is easy to solder, and has manifold uses for electrical purposes and making the finer alloys. During some of the recent years it appears that between 30 and 40 thousand tons have been produced in the United States; moreover, at a cost not much exceeding that of retort or furnace zinc.

Having prepared our technical notes or summary, from particulars given in the sequence of pages commencing with p. 281, we unexpectedly met with a nearly similar account (p. 255) of some of the operations, but with differences which cast a new light on the chemical aspect. It was impossible to avoid regret that it was apparently impracticable to unify both accounts or alternatively bring them into proximity. Cross-references between the two versions would have been a partial linking; but, at any rate, the p 251 sequence might have been included in the index under the heading "Zinc, Electrolytic," or under "Electrolytic Zinc."

The electrolyte now used is a somewhat acid sulphate solution obtained by the action of sulphuric acid on the roasted ore-concentrates. The crux of the method, however, is the purification of the solution from metals which are electronegative to zinc, such metals rendering effective electro-deposition impracticable by maculating the deposit which at a certain stage re-dissolves in the increasingly acid electrolyte by "local action," the maculated zinc acting like the copper zinc couple of Gladstone and Tribe When the impurity of the electrolyte is considerable, no zinc is deposited, but hydrogen rises from the cathode at the beginning Cobalt is notably subversive in the electrolyte solution, 15 parts per million inhibiting successful electrolysis Some of the methods of purification are extremely ingenious For example, if the iron content is below 0 3 gramme to the litre, it must be raised to this standard by the addition of an iron compound, after which the whole of the iron, together with some other metals, can be precipitated by lime The electrodes are of aluminium for cathode and of lead for the anode. Hence the fluid becomes increasingly acid as the electrolysis proceeds, and the exhausted fluid can be resaturated with zinc.

The account of photographic materials and processes is of special value as being comprehensive and exact; indeed, this section is a distinct credit to the book, but there might have been fuller indications as to which details are new in relation to the year 1920 Thus, in reference to a suggestion made in 1920 as to the practicability of using potassium cyanide for the fixing of gelatine emulsions, there might have been a mention of the fact that in the early stages of gelatine emulsion work, cyanide was frequently used, and that on p. 253 of the 1912 edition of Cassell's Cyclopaedia of photography there is a comparison of the relative advantages of cyanide and "hypo." Similarly, in making mention of recognition during 1920 of the colour sensitising properties of potassium iodide there is no clear demarcation between what is new and what is old. Reference may be made to pp. 67, 68 and Fig. 28 of the 1851

edition of Hunt's Photography, as illustrating one of the early mentions of sensitiveness to the red rays brought about by the use of potassium or sodium iodide. There may be doubt as to whether the action in this particular case is due to colour sensitizing in an ordinary sense of the term, as the effect may be partly thermic, or of a secondary nature, as extinguishing, continuating, protective, or exciting, all more or less considered on p. 359 of the second edition of Hunt's Researches on Light (1854) Researches and studies of this nature are often much complicated by the effects of minute traces of foreign matter in the materials.

GENERAL NOTE

AIR TRAFFIC FROM PARIS.—The air traffic from Paris to England and other European countries has increased 300 per cent. since a year ago, according to the statistics published by the French Air Minister. During the month of May this year, 593 aeroplanes left the air port at Le Bourget with 1532 passengers, as compared with 297 machines and 519 passengers during the corresponding month last year.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock.

NOVEMBER 23. — PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., Albert Medallist, "The Coming of Age of Long-Distance Wireless Telegraphy and some of its Scientific Problems" ("Trueman Wood" Lecture). ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council will preside.

NOVEMBER 30.—NOEL HEATON, B.Sc., "The Preservation of Stone." SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works and Public Buildings, will preside.

DECEMBER 7. —EMIL CAMMAERTS, "Literature and International Relations." H.E. the Belgian Ambassador will preside.

DECEMBER 14.—SIR WALTER BEAUPRE TOWNLEY, K.C.M.G., Minister to the Netherlands, 1917-19, "Trade with the Netherlands East Indies." THE RIGHT HON. LORD EMMOTT, G.C.M.G., G.B.E., will preside.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(Joint Meeting.)

At 4.0 p.m.

FRIDAY, NOVEMBER 25.—A. H. ASHBOLT, Agent-General for Tasmania, "An Imperial Airship Service." BRIG.-GENERAL LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., will preside.

DOMINIONS AND COLONIES SECTION.

At. 4.30 p.m.

TUESDAY, DECEMBER 6.—FREDERICK COATE WADE, B.A., K.C., Agent-General for British Columbia, "British Columbia—The Awakening of the Pacific." THE DUKE OF DEVONSHIRE, K.G., G.C.M.G., G.C.V.O., will preside.

Papers to be read after Christmas:—

LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

HOWARD MAURICE EDMUNDS, "Photo Sculpture."

CLOUDESLEY BRERETON, M.A., Divisional Inspector to the London County Council (Modern Languages), "Some Thoughts on Diction, and the Need of a National Conservatoire."

PHILIP SCHIDROWITZ, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

MAJOR PERCY A. MACMAHON, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "Electrical Driving in the Jute Industry."

W. A. APPLETON, C.B.E., Secretary to the General Federation of Trade Unions, "Economics and Labour."

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry."

ALEXANDER SCOTT, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum."

ARTHUR WILCOCK, "Surface Printing by Rollers in the Cotton Industry."

GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

J. H. HUXLEY, "The Control of Sex in Animals."

J. T. MARTEN, I.C.S., M.A., "The Indian Census" (Indian Section).

ALEXANDER L. HOWARD, "The Timbers of India and Burma." (Indian Section.)

PROFESSOR WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., "Brown Coals and Lignites: Their Importance to the Empire." (Joint Meeting, Dominions and Indian Sections.)

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India" (Indian Section).

F. G. ROYAL DAWSON, M.Inst.C.E., Chief Engineer to Indian Railway Board. "The Need for an All-Indian Gauge Policy." (Indian Section.) SIR HENRY PARSALL BURT, K.C.I.E., C.B.E., will preside.

PROFESSOR SIR THOMAS W. ARNOLD, C.I.E., Litt.D., M.A., Hon. Fellow of Magdalene College, Cambridge, *Sir George Birdwood Memorial Lecture.* (Indian Section.)

LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "Queensland." (Dominions and Colonies Section.)

CANTOR LECTURES.

At 8 0 p.m.

MONDAYS.—ARTHUR M. HIND, O.B.E., M.A., Assistant-Keeper, Department of Prints and Drawings, British Museum, and Slade Professor of Fine Art in the University of Oxford, "Processes of Engraving and Etching." Three Lectures.

Syllabus.

LECTURE I.—NOVEMBER 28.—Wood-cut.—The Process and its Origin—The Early Anonymous Woodcutters—Original and Reproduction Work—Wood-cut and Wood-engraving—The great designers for Wood-cut: Durer, Holbein and others—The special fitness of the Process for Book Illustration—Modern Work and its Scope.

LECTURE II.—DECEMBER 5.—Line-Engraving.—The Process and its Origin—Its Relation to the Work of the Goldsmith—The Great Masters of Original Engraving: Dürer, Marcantonio and others — Reproductive Engraving — Technical character of work in reference to the various aims of the Art.

LECTURE III —DECEMBER 12.—Etching —The Process and its Origin—Survey of work by the great original Etchers: Rembrandt, Van Dyck and others—Examination of the special qualities of Etching in relation to different kinds of work—Recent Etching.

C. AINSWORTH MITCHELL, M.A., F.I.C. "Inks." Three Lectures. January 23rd, 30th, and February 6th.

ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington. "The Mechanical Design of Scientific Instruments." Three Lectures. February 20, 27, and March 6.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constitutents of Essential Oils." Three Lectures. March 20, 27, April 3.

COBB LECTURES.

At 8.0 p.m.

MONDAYS, F. F. RENWICK, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MANN JUVENILE LECTURES.

At 3.0 p.m.

WEDNESDAYS, JANUARY 4 and 11, 1922, WILLIAM REGINALD ORMANDY, D.Sc., "Clay: What it is—Where it comes from—and What can be done with it."

MEETINGS OF SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 21 .. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Presidential address by Mr. G. Goodsir.

Electrical Engineers, Institution, of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Mr. A. J. Hainsworth, "Hydro-Electric Power."

Geographical Society, 135, New Bond Street, W., 8.30 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. G. H. Widdows, "School Design."

East India Association, 7, Tothill Street, Westminster, S.W., 3.30 p.m. Rev. Oswald Younghusband, "The English Boy in India."

TUESDAY NOVEMBER 22 .. Sociological Society at the Royal Society, Burlington House, 8.15 p.m. Mr. G. Russell, "The Causes of the Conflict between Great Britain and Ireland."

WEDNESDAY, NOVEMBER 23 .. ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. "Trueman Wood" Lecture. Prof. J. A. Fleming, "The Coming of Age of Long-Distance Wireless Telegraphy and some of its Scientific Problems."

Geological Society, Burlington House, W., 5.30 p.m.

Electrical Engineers, Institution of (South Midland Centre), The University of Birmingham, 7 p.m. Mr. W. Wilson, "Some Notes on the Design of Liquid Rheostats."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m.

THURSDAY, NOVEMBER 24 .. University of London, at the Imperial College of Science, South Kensington, S.W., 5.30 p.m. Mr. W. Bateson, "Recent Advances in Genetics." (Lecture IV.)

Antiquaries, Society of, Burlington House, W., 8.30 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. C. Hay-Murray, "Phrenology as an aid to Education."

Camera Club, 17, John Street, Adelphi, W.C., 8.15 p.m. Miss Olive Eddis, "A Colour Photography Trip in Canada."

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 8 p.m. Prof. P. J. Cheshire, "The Polariscope from a Historical Standpoint."

Mechanical Engineers, Instution of (N.-Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m. Dr. E. H. Salmon, "The Machinery of Floating Docks."

(Midland Branch), The University, Birmingham, 7 p.m. Mr. T. A. Pain, "The Equipment of a Modern Boiler House."

Chromatics, International College of, Caxton Hall, Westminster, S.W., 8 p.m. Dr. A. C. Crommelin, "Colour and the Stars."

FRIDAY, NOVEMBER 25 .. ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4 p.m. Dominions and Colonies and Indian Sections (Joint Meeting). Mr. A. H. Ashbolt, "An Imperial Airship Service."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Journal of the Royal Society of Arts.

No. 3,601. VOL. LXX.

FRIDAY, NOVEMBER 25, 1921

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W C. (2)

NOTICES.

NEXT WEEK.

MONDAY, NOVEMBER 28th, at 8 p.m. (Cantor Lecture.) ARTHUR M. HIND, O.B.E., M.A., Assistant-Keeper, Department of Prints and Drawings, British Museum, and Slade Professor of Fine Art in the University of Oxford, "Processes of Engraving and Etching." (Lecture I.)

WEDNESDAY, NOVEMBER 30th, at 4 30 p.m. (Ordinary Meeting.) NOEL HEATON, B.Sc, "The Preservation of Stone." SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works and Public Buildings, will preside.

NOTE -The attention of Fellows is drawn to the fact that the hour of this meeting has been changed from 8 p m to 4 30 p m

THIRD ORDINARY MEETING.

WEDNESDAY, NOVEMBER 16th, 1921; MR. BASIL OLIVER, F.R.I.B.A., in the chair.

The following candidates were proposed for election as Fellows of the Society:

Blagg, Percy, London
Elton-Bott, John Richard, Burma
Ross, Alexander G, Fiji
Sanders, Marion Eugénie, London
Wright, Hugh Francis, New Barnet, Herts

The candidates proposed at the opening meeting on November 2nd, of whom a list was published in the *Journal* of November 11th (pages 847-8), were duly elected Fellows of the Society.

A paper on "Modern Buildings in Cambridge, and their Architecture," was read by Mr. T. H. Lyon, M.A., Director of Design in the University School of Architecture, Cambridge.

The paper and discussion will be published in the *Journal* of December 2nd.

PROCEEDINGS OF THE SOCIETY.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 2nd, 1921.

MR ALAN A. CAMPBELL SWINTON, F.R S., Chairman of the Council, in the Chair.

THE CHAIRMAN, in opening the meeting, said it was the Inaugural Meeting of the 168th Session of the Society, and the Council had done him the very signal honour of electing him as Chairman of the Council for a fourth time. He believed that in the history of the Society only five previous Chairmen had been re-elected for a fourth time, viz., Mr. William Hawes, Sir Thomas Phillips, Lord Henry Gordon Lennox, Lord Alfred Spencer Churchill, and Sir Richard Webster (afterwards Lord Alverstone), and he wished to express to the Society and also to the Council his very high appreciation of the honour that they had done him.

His first business as Chairman was to present the Society's Medals to a number of eminent persons who had read papers before the Society. The recipients of the Medal on the present occasion were so very eminent that he could not help thinking that, in giving Medals to those distinguished persons, the Society was really not honouring them but honouring itself. At any rate, it was making the Medal of the Royal Society of Arts a very high distinction.

THE CHAIRMAN then presented the Medals to the following:

To those who have delivered the Trueman Wood Lecture.

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "Discovery and Invention" (1917).

SIR HERBERT JACKSON, K.B.E., F.R.S., "Glass and some of its Problems" (1919).

SIR OLIVER LODGE, D.Sc., Sc.D., LL.D., F.R.S., "Sources of Power known and unknown" (1919),

Sir Daniel Hall, K.C.B., F.R.S., "The Present Position of Research in Agriculture" (1920).

For the Sir George Birdwood Memorial Lecture:—

Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., M.C., "The Common Service of the British and Indian Peoples to the World."

For Papers read at the Ordinary Meetings:—

Major-General The Right Hon. Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., "Forestry."

Colonel Robert J. Stordy, C.B.E., D.S.O., "The Breeding of Sheep, Llamas, and Alpacas in Peru, with a view to supplying improved Raw Material to the Textile Trades."

Andrew Francis Baillie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World."

William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

Sir Kenneth Weldon Goadby, K.B.E., M.R.C.S., D.P.H., "Immunity and Industrial Disease."

For Papers read in the Indian Section.

William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

The Hon. Sir George Seymour Curtis, K.C.S.I., "The Development of Bombay."

For a Paper read in the Colonial Section:—

A. H. Ashbolt, Agent-General for Tasmania, "Industrial Development in Australia during and after the War."

For a Paper read at a Joint Meeting of the Indian and Colonial Sections:—

Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

The Chairman said that at the opening of the previous Session the Society was in a somewhat precarious position. Perhaps all the members of the Society were not so well aware of that fact as were the members of the Council. The House of the Society was erected for it by the brothers Adam some 150 years ago, upon the prevailing custom of a 99 years' lease, and the lease had long ago expired. It had been renewed from time to time by the proprietor, Mr. Drummond, but finally the Society had got down to a two years tenure, and at the beginning of last year it received an intimation that it must either pay a very much higher rent, a rent that it could hardly afford to pay, or buy the freehold. He need scarcely mention the fact that neither the previous nor the present year was a very suitable time for raising money, and the members of the Council were rather perturbed as to the outlook. They started a subscription list among their friends and promises were obtained of something like £10,000, but that was only a small amount compared with the value of the premises. However, during the year, thanks entirely to Mr. Menzies, the Secretary, the Society had had the good fortune to meet with a munificent benefactor who desired to remain anonymous, and who had paid into the Society's banking account the large sum of £30,000. With that sum and with the other sums already promised—and, of course, one could always borrow money upon a freehold—the Society was in a position to buy the building. But, as the members knew, a general appeal had just been issued to them for further subscriptions. It was desired not only to buy the freehold of the historic house, but also to add something to its amenities. The Council did not want to destroy a certain quaintness that there was about the rooms at the present time, for the Society had been occupying those rooms for more than 150 years, but wished to make various improvements. The lecture hall required painting, the library needed renovating, a smoking room and a cloak room should be provided, and so forth. The Council was, therefore, anxious to enlist the sympathy of the members of the Society to produce a certain amount of money besides that which had already been given. The appeal was only sent out on the previous day, but a gratifying number of responses had already been received. It must be understood that a Society such as the Royal Society of Arts was very much affected by the increased cost of things in general and more especially of printing. The cost of the Society's *Journal*, which was published weekly, was in 1913/1914 £1,767, and in 1920 that sum had increased to £4,541, although the number of pages in the *Journal* was reduced from 1,050 to 840. By printing the *Journal* in the country during the present year, however, there would be a considerable saving. From January to August, 1921,

it cost £2,477 as against £2,814 in the corresponding months of 1920, a reduction of £337. That reduction would have been £600 had not the postage been increased from a half-penny to a penny. It was probable that the cost of production would diminish slightly. Already the printers had agreed to a reduction of 5 per cent., and a further reduction of 5 per cent. later had been promised. He mentioned those figures to show the difficulties of such a Society at the present time. As the members knew, the subscription had been increased, and that had had a gratifying result. It was realised that the increase of the subscription would probably bring about a certain number of resignations. An increase of subscription invariably had that effect, not only in the case of Societies such as the Royal Society of Arts, but in the case of clubs and other bodies. The result of the increase was as follows: From January 1st to October 31st, 1920, the subscriptions amounted to £4,454, and for the same period in 1921, they amounted to £5,561, or an increase of over £1,000. It was, therefore, clear that the policy of increasing the subscription from two guineas to three guineas per annum was going to increase the revenues of the Society, although it had unfortunately brought about a certain number of resignations It was now for the members of the Society to induce their friends to join in order to make up the loss in numbers that had been sustained. The loss was only 260 out of a total of 3,200, so that he thought a little propaganda on the part of the members would bring the membership back to its former level.

As the present meeting was the first that had taken place since the Society received the munificent anonymous gift of £30,000 to which he had referred, he wished to propose that the following resolution should be passed:—

"That this Society, at the opening meeting of their 168th Session, do instruct the Secretary to convey their most grateful thanks to the anonymous benefactor who, by his munificent gift of £30,000, will enable them to complete the purchase of the historic house which was built for them by the brothers Adam and which they have occupied for over a century and a half, and has also enabled them to carry on with unabated vigour their work for the encouragement of arts, manufactures and commerce, in which they have been continually engaged since 1754."

If the meeting would pass that resolution, the Secretary, who knew the name of the donor, would convey the resolution to him.

The resolution was carried with acclamation.

THE CHAIRMAN then delivered the following address:—

WIRELESS TELEGRAPHY.

AN ADDRESS

Delivered at the opening meeting of the 168th Session of the Royal Society of Arts on the 2nd November, 1921.

By ALAN A. CAMPBELL SWINTON, F.R.S., M.Inst.C.E., M.I.E.E., M.I.Mech.E., Chairman of the Council of the Society.

The subject of wireless telegraphy appeals so much to everybody at the present time, that I do not know that I need apologize for giving you an address on that subject. I chose the same subject for my address last year, but it is of perennial interest. Furthermore, if I again go over a certain amount of old ground, I hope that in doing so I shall be able further to elucidate points that, so far, at any rate to the man in the street, are not altogether plain.

As I have previously shown in this room, for the reception of messages from the more powerful wireless stations, it is not necessary to employ an external aerial, all that is required being a comparatively small coil of wires called a frame or loop aerial, such as is illustrated in Fig. 1. As is well known, a frame of this descritpion has directional properties; that is to say, it receives best when the plane of the frame is set in the direction from or to which the wireless waves are travelling. When the plane of the frame is set at right angles to the direction of the waves, then reception ceases. This minimum position, when signals cease to be heard in the telephones, is more sharply defined than the maximum position when the signals are loudest; so, to find the direction of the sending station, the practice is to employ the minimum position of the frame when one knows that the direction of the station is exactly at right angles to this position.

The explanation that is usually given of the working of a frame aerial of this kind is, that when the waves strike

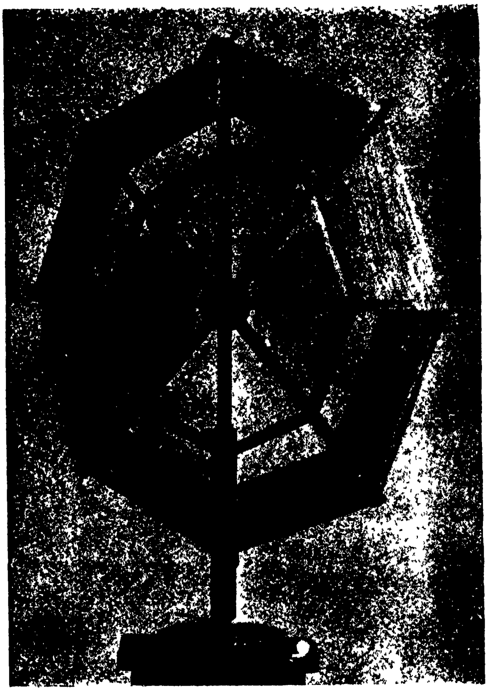

FIG. 1 FRAME AERIAL.

the wires on the near side of the frame they are in a slightly different condition of phase than they are when they strike the wires on the further side of the frame. To take an extreme case, if the distance between the two sides of the frame were equal to one-half a wave length, then it is clear that the waves, when they strike the wires on the near side of the frame would be exactly in opposite phase to what they would be when they strike the wires on the further side. Of course, as a rule, the frame is very much smaller than half a wave length in size. For instance this frame is only 1 metre across, whereas the waves from the Eiffel Tower are 2,600 metres in length, and half a wave length would be 1,300 metres. The difference in phase, therefore, on the two sides of a frame such as is shown is very small, but still, it is sufficient to cause oscillatory electric currents to travel round and round the wires of the frame corresponding to the wave frequency.

Mr. R. C. Clinker, of Rugby, has kindly lent me a very pretty model illustrating the action of a frame, a photograph of which model is shown in Fig. 2.

The model consists of a horizontal sliding wood piece having a sinuous upper edge which operates upon two vertical sliders carrying arrow heads, which can be set at different distances apart. The horizontal motion represents the passage of an electric wave across the vertical sides of a rectangular coil, and the vertical motions of the arrows show the amplitudes and phases of the electro-motive forces induced in the sides of the coil. The resultant E.M.F. available at any instant is the vertical distance between the arrow tips as shown on the scale. With the sliders set close

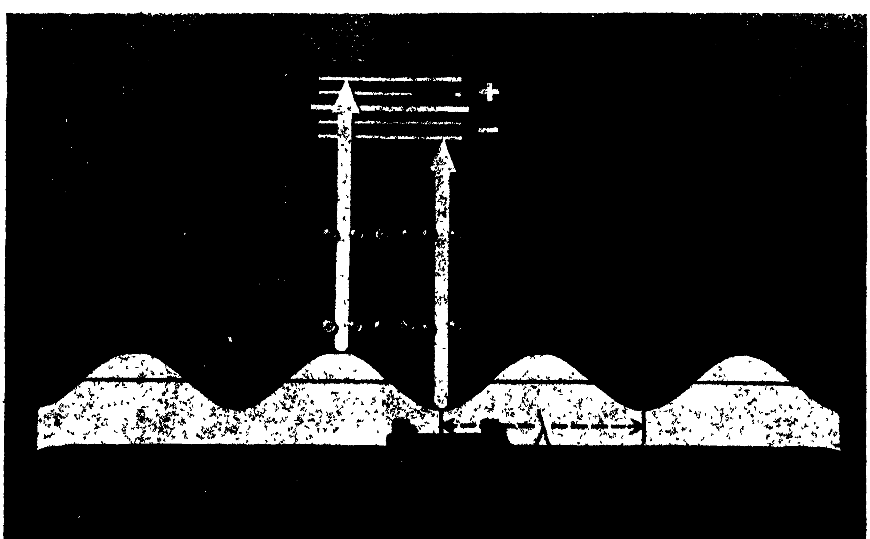

FIG. 2. MODEL TO ILLUSTRATE WORKING OF FRAME AERIAL

together, this distance is small compared with the total distance moved by each slider. With the sliders set further apart this distance becomes larger, until, with the sliders at a half wave length apart, the maximum is obtained. This illustrates the fact that the useful E.M.F. of a frame aerial is only an exceedingly small difference between two large quantities, as the width of the frame is generally a very small fraction of the wave length. If, in the model, the two sliders are placed at the same point of the wave (for which double rollers are provided), the same vertical motion is obtained as before, but there is no distance between the tips, i.e., no useful E.M.F. is produced. This represents the case where the receiving frame is turned so that its plane lies at right-angles to the direction of the wave travel, when no signals are obtained.

As mentioned, it is by taking into account the difference in phase on the two sides of the frame that its working is usually explained; but some months ago Sir Oliver Lodge gave me an explanation which I think in some ways is more easy to understand. The waves sent out by wireless stations are electromagnetic waves, which consist of two components, one electric and the other magnetic. The electric component is vertical to the ground from which it follows that the magnetic component is horizontal. When, therefore, the frame is turned so that its plane is in the direction of the travel of the waves, the magnetic component passes backwards and forwards through the interior of the frame. This has just the same effect as if you thrust a magnet in and out of a coil of wire, which, as you know, causes a current of electricity to pass in the coil first in one direction and then in the other, as the magnet advances or recedes. Similarly, as these magnetic pulses oscillate backwards and forwards through the coil of which the frame aerial consists, electric currents are caused to oscillate backwards and forwards through the coil with the same frequency as the oscillations of these magnetic pulses.

In some ways, perhaps, this is a simpler explanation than the one usually given; it is based on the idea that it is the magnetic component of electromagnetic waves which is chiefly active in operating a frame aerial, just as it is probably chiefly the electric component which operates a tall external aerial reaching up into the sky.

In the particular frame aerial shown in Fig. 1, there are altogether 100 turns of wire spaced so that the various turns are not in contact, the spacing being for the purpose of reducing the electrostatic capacity between the turns. Arrangements are made, further, by means of plug connections, whereby either the whole 100 turns can be employed, such as are required for receiving very long waves up to 20,000 meters, or a lesser number of turns, say 50, 35, or 15, can be used. For a medium wave station such as the Eiffel Tower, whose wave length is 2,600 metres, either the 35 turns or 50 turns will suffice, the only difference being that when 35 turns are used the tuning condenser, which is connected across the ends of the coil, has to be adjusted to give a rather larger capacity than when 50 turns are employed, when the tuning capacity has to be reduced almost to nothing.

As will be observed in the frame aerial illustrated, the turns of wire are arranged in two sets of 50 turns each, each 50 turns being wound radially so that each succeeding turn is outside the one before it. This is one way of winding these frames; but another way is to wind all the turns side by side so as to form a cylindrical spiral, all the turns being parallel and of the same diameter. The two methods of winding do not appear to differ very much so far as practical results are concerned, but theoretically, at any rate, the radial form of winding should give the sharpest position of silence which indicates that the plane of the frame is at right angles to the direction from which the waves are coming, whereas the parallel form of winding should give the most sharply defined position of maximum strength of signals such as is obtained when the plane of the coil corresponds with the exact direction of the waves, this for the reason that, with the parallel form of winding when the plane of the frame corresponds with the direction of the waves, the latter will reach all the wires at one side of the frame at the same instant, whereas with the radially-wound frame, this occurs when the plane of the frame is at right angles to the direction of the waves.

In either case, of course, the frame aerial merely indicates the general direction of the waves, but leaves undetermined the absolute direction, that is to say, it will not tell you whether the sending station is to the north or south, but merely that it is, in one or other of these directions.

In order to arrive at a method of finding the absolute direction, I recently carried out a series of experiments in which the frame, which was a small one only one foot in diameter, but with which signals from the Eiffel Tower, Paris, were easily received, was placed in a copper box in the form of a cube two feet dimensions in each direction, made of sheet copper about $\frac{1}{32}$ inch. in thickness. This box was completely closed in with soldered joints, excepting on one side, which was open, but could be closed by means of a close-fitting lid also made of similar sheet copper. In all the experiments, the copper box was connected to earth.

Preliminary experiments, in which only the frame aerial was enclosed in the copper box—the amplifier, tuning condenser, telephone receiver, and batteries being outside—having proved unreliable owing, apparently, to the outside apparatus picking up the waves irrespective of the frame, it was decided to put the whole of the apparatus and connections, as well as the frame, inside the box, and to listen to the telephone receiver through a ½-inch rubber tube passed into the box through a round hole in the latter. Considerable trouble was experienced in getting the apparatus to work properly under these conditions, the close proximity of the frame and the amplifier causing reactions that were apt to lead to automatic howling, but with care, clear signals were obtained.

Experiments were made with the 2600-metre spark emission from the Eiffel Tower.

Though putting the frame and other apparatus into the box greatly reduced the strength of the received signals, still, when the frame was pointed in the right direction, with the open side of the copper box turned towards Paris, the signals could be heard quite easily. They were probably only about five per cent. of the strength obtained with the frame completely unshielded.

On closing up the open side of the box with the copper lid, it was found that as the lid was put on, the signals further gradually diminished in strength. They were, however, still distinctly audible so long as the narrowest possible slit or opening was left. Indeed, they only disappeared, and did so quite suddenly, when the edges of the lid came into actual contact with the box so as to form a closed continuous electrical conductor round the frame. With the lid quite closed, and making good electrical contact all round, no trace of the signals could be heard.

Experiments were also tried with a lid consisting of thin tin-foil pasted on wood, in place of the copper lid. This lid was just as effective as the copper one in stopping the signals. When the tin-foil lid completely closed the aperture and made good contact all round with the copper box, no trace of any signals could be obtained.

As mentioned, all these results were obtained with the open side of the box facing Paris, but exactly similar results, with no distinguishable difference as regards the strength of the received signals, were obtained when the box was turned round so that its open side was pointing in the exactly opposite direction from Paris. By such means it is therefore not possible to ascertain the absolute direction of the waves any better than with an unshielded frame.

With the box turned so that its open side pointed in a direction at right angles to the direction of Paris, either to the right or to the left, but with the frame pointing in the direction of Paris, no signals at all could be heard, though the side of the box was completely open; but with the box so placed that its open side pointed in a direction making an angle of 45 degrees with the direction of Paris, with the frame pointing in the same direction or more towards Paris, the signals could be heard, though faintly, being reduced to some 1 per cent. of their value with the frame completely unshielded.

For any signals to be heard, it was, however, essential that the relative positions of the box and frame were such that a prolongation of the plane of the frame towards or away from Paris, no matter which, came out of the open side of the box, clear of the copper sides.

With the box turned up so that its open side pointed to the sky, with the vertical frame pointing to Paris, the signals could be heard at about 1 per cent. of their full unshielded value, and disappeared when the lid was put on, in exactly the same way as when the open side of the box was pointing to, or directly away from Paris.

From these experiments it would appear that waves of the length and strength of those experimented with do not penetrate into a completely closed metallic box to a sufficient extent to give audible signals

with a frame aerial and amplifier of the description used, even if the side of the box facing the source of the waves is only closed with tin foil. Further, it would seem that the screening effect is largely a matter of a closed electrical conducting circuit in that portion of the box that surrounds the periphery of the frame, the smallest break in the electrical conducting continuity interfering largely with the screening effect

That this is so, is shown by further experiments made with a flat sheet of tin plate, 5 feet in length and 8 inches wide, bent so as to form a cylinder This was placed over the frame so that the axis of the cylinder coincided with that of the frame With the ends of the tin plate

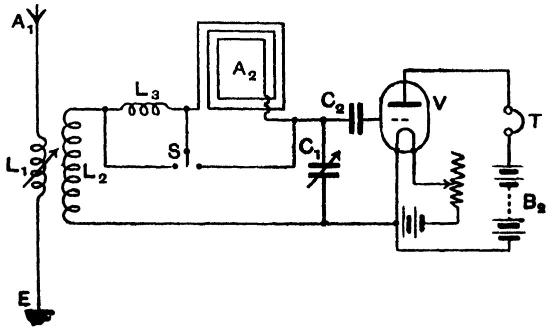

FIG 3 UNITED STATES NAVY WIRELESS COMPASS

sheet overlapping, but not in electrical contact, the effect in reducing the strength of the signals was small, but immediately increased considerably, so that the signals were reduced to about 20 per cent of their original strength, when the ends of the sheet were allowed to touch so as to form a continuous conducting ring round the periphery of the frame Contracting the diameter of the ring by sliding the overlapping ends of the plate so that the ring was closer to the frame all round, still further reduced the strength of the signals, till when the ring was touching the insulated wires of the frame all round, the signals very nearly disappeared. This indicates that the effect is not merely a question of screening, but also of eddy current damping, which was further shown by contracting the tin plate cylinder still further, and placing it inside the frame, where it again had the effect of largely reducing the strength of the signals. That damping enters largely into the matter was also proved by placing a large flat copper plate close up to one side of the frame, where it could have no screening but only a damping effect, which also greatly diminished the strength of the signals.

The result obtained with the frame inside the copper box, in getting signals of equal strength with the open side of the box facing away from the source of the waves, as when the open side faced towards such source, may, perhaps, be of some interest from the point of view of theory, in throwing some light upon the mechanism of electro magnetic wave phenomena

Though these results are of value, as you see, they do not solve the problem of enabling the frame to indicate the absolute direction However, this can be done by employing, in conjunction with the frame, an ordinary small external aerial Fig 3 shows the connections in this arrangement, which goes by the name of the United States Navy Wireless Compass In the illustration, A1 is the external aerial, A2 the frame aerial, L1 and L2 is the usual loose coupled tuner, while L3 is an inductance which is made of exactly the same value as the inductance of the frame C1 is the usual tuning condenser, while V is the valve connected with the telephone T and the battery B In practice, of course except for very loud and near stations several valves would be employed to produce the necessary amplification

As will be seen, by means of the switch S, either the frame A2 or the inductance L3 can be connected in series with the secondary (L2) of the loose coupled tuner When the switch is turned to the right the frame is short circuited, and the signals received are those coming from the external aerial A1 When the switch is turned to the left, the frame aerial A2 is put in series with L2, so that the signals received are the combined result of what is caught by the external aerial and the frame By means

of the loose coupling of the tuner, the strength of the signals received from the two aerials can be balanced until they are about equal. Then, if the frame is turned in one direction, the signals that are caught by the frame reinforce those that are caught by the external aerial; whereas, if the frame be now turned through 180 degrees so as to point exactly the opposite way, the signals caught by the frame interfere with those caught by the external aerial. In this way, with the frame pointing in one direction very much louder signals are obtained than when the frame is pointing in the opposite direction, and the apparatus having been calibrated upon a station the absolute direction of which is known, it will serve to tell the absolute direction of other stations. The reason for inserting the inductance L3, which has the same inductance as that of the frame, is so as not to interfere with the tuning when the switch S is turned one way or the other. Much sharper direction finding can be obtained with the frame alone: so in practice, with this apparatus, fine readings of the direction are taken with the frame alone, and readings for the absolute direction with the two aerials used conjointly.

I must now explain to you some more of the apparatus with which we are going to show experiments this evening, and, first of all, I will begin with the six-valve amplifier, the front appearance of which is shown in Fig. 5, while the back is shown in Fig. 6; Fig. 4 being a diagram of the connections.

In my address last year, as you may remember, I described a seven-valve amplifier of the resistance type. The amplifier which I am showing this evening is not a resistance amplifier, but is what is called a transformer amplifier, connection from the plate of one valve to the grid of the next valve being by means of small transformers.

The production of an amplifier that will respond equally well to all wave lengths, from the 180-metre wave length imposed by the authorities for many amateur stations up to the 20,000-metre wave lengths, and more, in use in several of the Continental and American stations, is a matter of considerable interest to all scientific investigators.

In many commercial stations, as, for instance, in those on board ship, as a rule only a very limited range of wave lengths is dealt with, so that the usual design of amplifier can be made to give effective results over the whole range that is required. In the larger receiving stations, moreover, there is no difficulty in providing several separate amplifiers suited for a number of particular wave lengths. When, however, we come to the ordinary experimenter, this individual usually wishes to be able to receive efficiently both the shortest and the longest wave lengths that are emitted, while, at the same time, by reason of the expense, and also owing to the exigencies of space, in this case a number of separate amplifiers are usually out of the question. Thus probably only one amplifier is provided, and this is usually only really efficient for waves of medium length, giving inferior results, both with very short waves and with very long ones.

The so-called resistance form of amplifier, in which succeeding valves are connected together by small condensers, is probably the form of instrument that, without alteration or adjustment, will give the greatest range as regards wave lengths. Unfortunately, however, resistance amplifiers do not appear to be at all suitable for short waves; indeed, they only begin to become effective with wave lengths of about 1,000 metres. Again, even for long waves, resistance amplifiers appear to require more valves than do transformer amplifiers in order to get the same result, in the proportion of seven or eight as against six.

No doubt transformer amplifiers can be made to operate with a wide range of wave lengths by employing transformers with tappings on the primary, and perhaps best also on the secondary circuits, so that the number of primary and secondary turns in use can be varied at will. Such arrangements, however, require complicated switching devices which, unless very skilfully constructed, are very apt to give trouble, while there is the objection that the electrostatic capacity of the unused turns is apt to cause a certain loss in efficiency.

A very simple solution of the problem has been recently suggested. Mr. H. H. T. Burbury has had the happy idea of constructing a six-stage amplifier in which the first three transformers, which are of the air-core variety suitable for radio-frequency, are made readily removable, each being fitted with four pins connected to the ends of the primary and secondary circuits, exactly similar to the pins at the base of the "R" valve, while "R" valve sockets of the usual construction are employed for the transformers to fit into.

A number of different sets of transformers, wound with different numbers of turns to suit different wave lengths, can thus be used; while to bridge over the difference between one set of transformers, each with a particular number of turns, and the next set, each with a larger number of turns, and thus obtain proper resonance, adjustable condensers are employed across the primaries of the transformers. In this way, with a sufficient number of interchangeable transformers, the best possible results can be obtained on a single instrument with any wave length.

The amplifier which is shown is constructed on this principle.

The instrument is, as you will see, a six-stage amplifier, the first three valves being operated at radio-frequency, while the fourth is a detector valve supplied through a leaky condenser, the last two valves operating at audio-frequency.

Each of the first three air-core radio-frequency transformers consists simply of a flat circular disc or bobbin of ebonite, with a groove round the periphery in which the primary and secondary coils are wound. In most cases the primary and secondary are wound simultaneously off two spools in the same groove, the primary and secondary having an equal number of turns; but in other cases the primary and secondary have been wound in two separate grooves close together.

In connection with this point it may be of interest to mention that Mr. Burbury has tested the relative advantages of winding the primary and secondary in separate grooves, or in the same groove, employing two separate coils the distance between which could be varied so as to change the amount of coupling. He found that, in spite of what the text books say, the tighter the coupling the better, and so now prefers to wind his primary and secondary together in the same groove. When this is done, however, it is necessary to give careful attention to the insulation of the wires, as otherwise a short circuit may prove disastrous.

For receiving 300-metre waves, 50 turns for both primary and secondary will be found sufficient, while 100 turns give good results for 600-metre waves. For longer waves, say, of 1,000 metres and upwards, we have transformers in which primary and secondary have each 250, 400, 650, 1,000 and 2,500 turns, the latter being suitable for receiving Carnarvon, Lyons and Lafayette, near Bordeaux, the last having, it is understood, a wave length of 23,450 metres.

A complete diagram of the connections of the six-valve amplifier is shown in Fig. 6 in which V_1 V_2 V_3 are the three valves working at radio-frequency. V_4 is the detector valve, and V_5 and V_6 valves work at audio-frequency.

T_1 T_2 T_3 are the three removable radio frequency transformers, while T_4 and T_5 are fixed audio-frequency transformers, iron-cased and with iron cores, with step-up transformation of 1 to 5.

The adjustable tuning condensers C_2

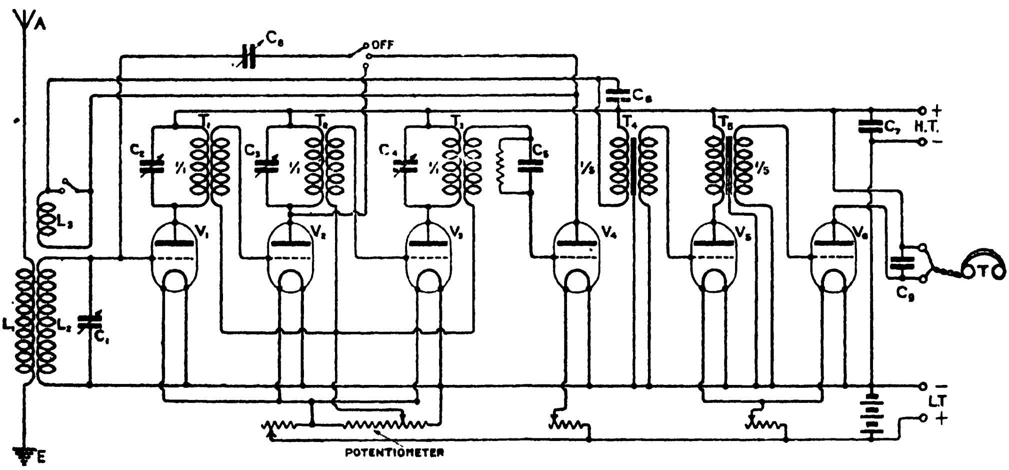

FIG 4 UNIVERSAL AMPLIFIER; CONNECTIONS

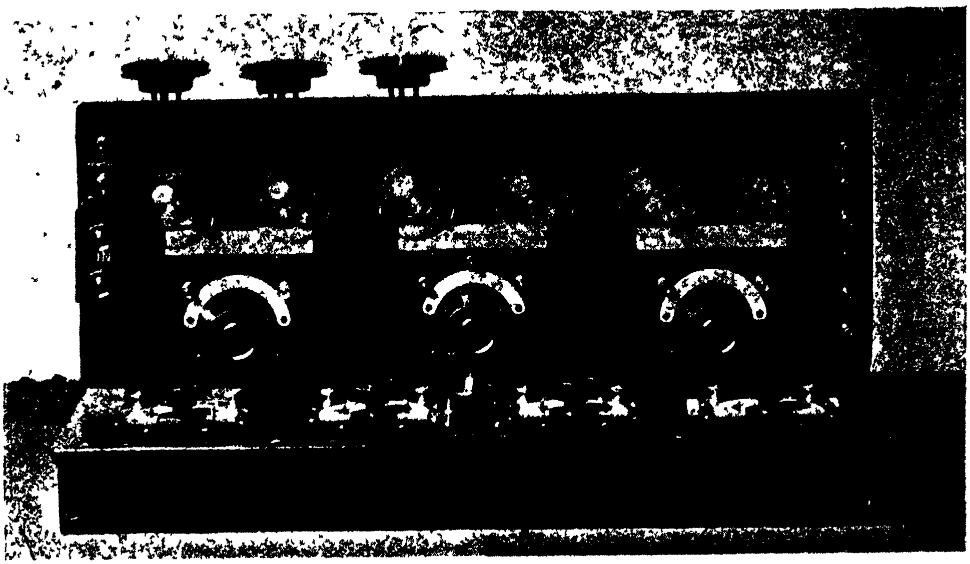

FIG. UNIVERSAL AMPLIFIER ; FRONT VIEW

C_3 and C_4 are connected across the primary windings of the radio-frequency transformers. By means of a toothed rack and gear wheels, they are all connected together, so that one adjustment alters all three condensers simultaneously.

The leaky condenser, C_5 is employed to produce detection in valve V_4.

A small condenser, C_6, is used to by-pass, for high-frequency currents, the primary of the audio-frequency transformer, T_4. The usual condensers, C_7 ond C_9, are also connected across the high-tension battery and the telephones. A potentiometer is employed to control the grid voltage of valves V_2 V_3 and V_1, while the two audio-frequency valves and the detector valve have separate rheostatic controls to their filaments from the three other valves.

The instrument is arranged so that either magnetic or electrostatic reaction can be employed. As shown, the magnetic reaction is obtained by means of a coil connected between the plate of the fourth valve and the primary of the transformer, T_4. A switch is used to short-circuit this reaction coil when not in use. Provision is also made for electrostatic reaction between the plate of either the second or fourth valve and the grid of the first valve through a small adjustable condenser, C_8.

For the reception of C.W. signals, either the magnetic or the electrostatic reaction can be used to make the instrument self-heterodyning, or a separate heterodyne can be employed

Fig. 5 shows the appearance of the front of the instrument. The input terminals, as also those for connecting the magnetic reaction coil, are on the left, while all the other terminals are on the right. The three removable radio-frequency transformers, with their connection pins, will be observed at the top on the left. The potentiometer is on the centre of the upright part of the instrument, with the filament-control rheostats on each side of it, while below are the three tuning condensers for the radio-frequency transformers and the adjustable condenser for capacity reaction. In the centre, below the potentiometer, is a three-way switch for connecting the capacity reaction condenser to the plate of the second or fourth valve, or for disconnecting it.

Fig. 6 shows the back view of the instrument, with the three radio-frequency transformers on the right, at the top, and the two audio-frequency transformers on the left. The leaky condenser and its leak are at the bottom, and the by-pass condenser, C_6, and the telephone condenser, C_9, at the top, on the left. The back of the valve sockets and of the potentiometer, and one filament rheostat, are also visible.

As loud-speaking telephones to make Morse signals, speech and music audible throughout the room, we have both one of Mr. Sidney Brown's well-known reed instruments, fitted with a specially large trumpet, and with a special diaphragm, and also an example of the American

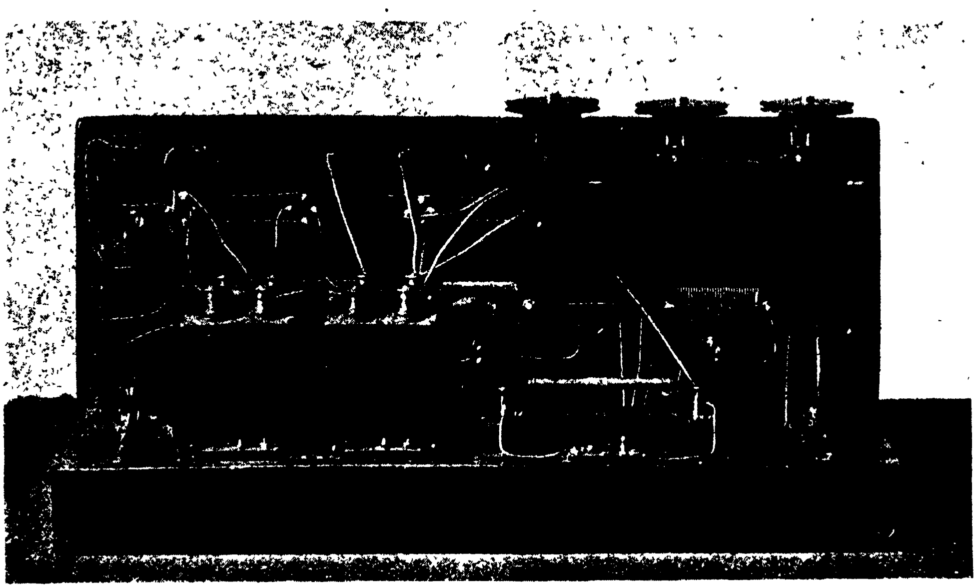

FIG. 6. UNIVERSAL AMPLIFIER ; BACK VIEW.

instrument known as the Magnavox. This latter instrument differs from ordinary telephone receivers inasmuch as the vibrations of the diaphragm are caused by the varying electric currents passing in a circular coil of wire attached to the diaphragm, which coil is placed in a very powerful magnetic field produced by a battery current through an electro-magnet. The two poles of this electro-magnet are concentric one inside the other, leaving between them an annular space in which the coil is free to vibrate and across which the magnetic field is radial. So long as there is no current flowing through the coil, there is no initial pull on the diaphragm, as there is in ordinary magnetic telephones, so that it is claimed the diaphragm is more free to move in exact accordance with the wave form of the actuating electric current.

On the occasion of a recent trip to Paris, I visited, at Levallois Perret, the receiving station of the Société Française Radio-Electrique, where long-wave messages and signals from Annapolis, near New York, and other American stations are photographically recorded. The signals are received on a large frame aerial some three metres in diameter, mounted inside the loft of a three-storey building, the amplifiers and other receiving instruments being on the ground floor immediately below the frame aerial. All the receiving instruments are contained, in a windowless copper room; that is to say, a room large enough to contain the instruments and operators, which is covered all over, top, sides and even the door, with sheet copper connected to earth. This arrangement is employed to shield the instruments from disturbances, the station being situated in the middle of works where many electrical experiments are constantly being made. The frame aerial, which is of cylindrical form, is connected to the amplifiers through a step-up high frequency transformer, the primary consisting of a few thick turns, and the secondary of many turns of smaller wire. There is nothing very special about the amplifier, which is of the transformer type, excepting that the transformers, though used for high frequency currents, have iron cores, the iron being of special quality and very finely divided. Furthermore, the transformers are shielded from outside influence and from one another by being separately enclosed each in a sheet-iron box. After being amplified, the signals are very clear and loud; indeed, an American station near Panama which was sending on the occasion of my visit, could be heard all over the room. For the purpose of getting rid of atmospheric disturbances which, on these long-distance transmissions are apt to have particularly baneful effects, what is known in America as an "x-stopper" is employed. This is an instrument in which the plate currents from the amplifier are caused to pass through two circuits,

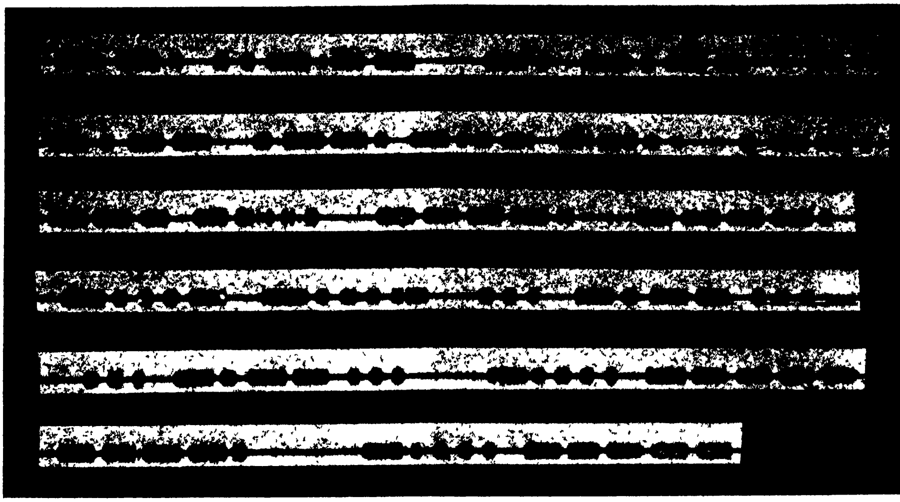

FIG. 7. PARIS OSCILLOGRAPH RECORD OF AMERICAN STATION

so arranged that, by acting on one another they reduce the sounds due to atmospherics to a greater extent than they reduce the sound of the signals. This they do by taking advantage of the fact that, whereas the signal waves are tuned to some definite wave length, the waves due to atmospherics are untuned, and have no definite wave length. As a result, though the strength of signals is also somewhat reduced, the disturbances due to atmospherics are almost entirely eliminated. For finally recording the signals an oscillograph of the Blondel, or Duddell type is employed. This consists of a narrow strip of phosphor bronze stretched to the requisite tension to make it respond readily to the audio-frequency of the electric currents from the amplifier, which are passed through it after being transformed by a step-down transformer, which reduces their voltage and increases their amperage. The phosphor bronze strip is mounted in a very intense magnetic field which causes it to assume rapid vibration when furnished with current of the appropriate frequency. On the centre of the strip is mounted a small mirror from which a narrow pencil of intense light from an arc lamp is reflected on to a moving band of photographic paper. When the strip and mirror are at rest, the pencil of light is focussed to a point on the centre of the paper band, and as the latter moves, it draws a straight line along the centre of the band. When, however, the strip and mirror are put into vibration, the spot of light vibrates across the paper band at right angles to its length, on both sides of the central line. The vibrations are too rapid relatively to the speed of the paper band to show individually, the result being to give on the developed paper the effect of a number of elongated beads upon the central line, a short bead representing a dot and a long bead a dash of the Morse alphabet. Fig. 7 shows a reproduction of some of the records obtained with this instrument in my presence. The machine is self-acting, the photographic paper, after having been exposed to the vibrating spot of light, passing automatically successively through developing, fixing and washing baths. The chief advantage of the arrangement is the fact that it can operate at very great speeds up to 200 words a minute when automatic sending is employed at the transmitting station. For ordinary speeds a siphon recorder or Morse inker would be a much simpler and more economical arrangement, and either could, I think, be got to work well on the strength of signal that I heard at Lavallois.

Another method of recording employed at Levallois consisted in the employment of a phonograph, the vibrations of the receiving telephone being used to operate a stylus engraving on wax in the ordinary way. When high-speed messages are being received, the phonograph is run very fast, while afterwards, the messages can be reproduced on a much slower running phonograph. In this way, it is possible to decipher by ear and write down messages which have been sent at far higher speeds than

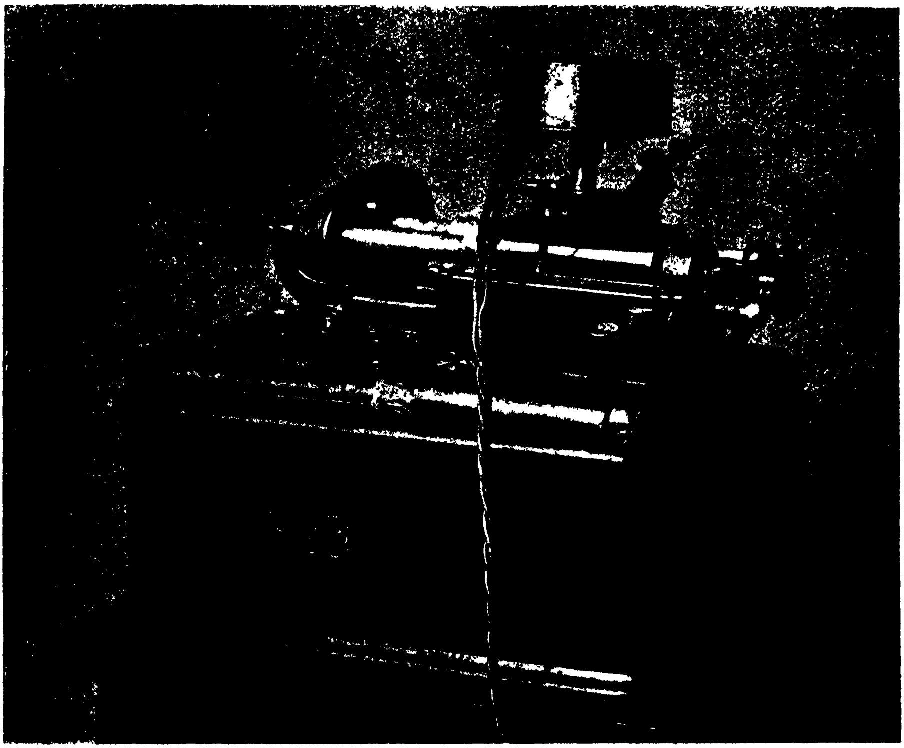

FIG. 8. PHONOGRAPH FITTED WITH TELEPHONE RECEIVER

could be recorded by anything other than automatic apparatus.

A phonograph fitted for the receiving of wireless messages in this manner is shown in Fig. 8. As will be seen, it is an ordinary Edison phonograph of the type that is now called a Dictaphone, though actually of much older make. The wax cylinder on which messages are recorded is in a horizontal position near the top of the instrument, the base of which contains a slow running electric motor which causes the wax cylinder to rotate. Above the cylinder is an arm which carries the recording diaphragm connected to a small sapphire point or chisel, which cuts a groove of varying depth on the wax as the cylinder rotates, as the diaphragm vibrates, and as the arm and chisel are caused to travel along a line parallel to the cylinder's axis. Above the diaphragm is mounted a Brown loud-speaking telephone receiver, minus its horn, any sounds of sufficient loudness, whether in the shape of Morse signals, or of music, or of speech, emitted by the loud-speaker being communicated to the engraving stylus, and recorded as indentations on the wax. It will be understood that in this case there are two diaphragms, one, the diaphragm of the Brown loud-speaker, and the other the diaphragm of the phonograph, and that the former impresses its vibrations on the latter through a column of air of a couple of inches in length. This works quite well, provided the sounds are sufficiently loud, but no doubt a more sensitive arrangement would be obtained if both the diaphragms and the intervening column of air were suppressed, and the recording stylus connected directly to the vibrating reed of the Brown telephone. As you will hear, the instrument records wireless Morse signals very perfectly, and reproduces them in so good a manner that it is often difficult to distinguish the reproduction from the original. Music and speech are also reproduced with clearness, even when the original music sent by wireless is the result of a gramophone playing at the far end. In such a case, it is to be remembered that there are no less than eight transformations : (1) Sound to record : (2) record to sound : (3) sound to variations in electric current : (4) electric current variation to modulated electric waves : (5) modulated electric waves

to electric current variation: (6) electric current variation to sound: (7) sound to record: (8) record again to sound.

It is really surprising after so many transformations that the final result retains so much of the quality and other peculiarities of the original.

I will now start the phonograph going, and you will hear both Morse messages that have been recorded by wireless from Paris, Berlin, Moscow, Madrid and other distant places; and also actual speech and music transmitted over distances of several miles.

We will now put the amplifier into operation and listen for a transmission of wireless telegraphy sent from my office in Victoria Street, with the very small power of only about 10 watts. For the reception of this we must, of course, use the external aerial that we have put up on the roof, as the frame aerial could not be expected to receive with such a small amount of power. As you hear, Victoria Street is now sending in Morse signals the call sign "2 H K," which has been assigned to it by the Post Office. Having sent the call sign, a lady in Victoria Street is now going to sing. As I think you are able to recognise, the song is "Annie Laurie."

We are now going to have some more wireless speech and music transmitted to us by Mr. W. W. Burnham, from Lewisham. This is on a very short wave length, and, therefore, we expect to have no interference from other stations, because no one else is likely to be sending on such a short wave length.

For receiving this transmission from Lewisham we shall use a special arrangement of three-valve amplifier and two-valve note magnifier kindly lent for the purpose by Mr. Burnham.

The amplifier has three valves operating respectively as high frequency amplifier, detector and low frequency amplifier. Switches are provided, permitting the valves to be used in four different ways, viz.: (1) single valve, as detector amplifier; (2) two valve, one high frequency, one detector; (3) two valve, one detector, one low frequency: (4) three valve, one high frequency. one detector, one low frequency. The high frequency valve operates by means of capacity-reactance coupling for waves from 150 to 5,000 meters in length, and by capacity-resistance coupling for waves over 5,000 meters. A special design of circuit is used in which each valve has its own filament rheostat, such rheostats being used to control the grid potential of the valves in addition to their usual function. The grid of the high frequency valve is normally operated about four volts positive, but the damping so introduced is destroyed by the use of magnetic reaction taken from the plate of the detector valve. Contrary to most high frequency amplifiers, the reaction is quite as easily controlled as in a one valve set, and there is no tendency for the set to fly into oscillation.

Owing to the introduction of damping on the first grid and its subsequent destruction by resonance of the reaction coil, the apparatus is remarkably selective in that it gives optimum amplification only on the particular wave length at which it is being operated.

As you hear, Mr. Burnham is now addressing the meeting by wireless from Lewisham, and now you can hear "Land of Hope and Glory" played at Lewisham on a gramophone. In addition to your hearing this, we are taking it down on the phonograph, and later on we will let you hear the music again from the phonographic record. Here it is, and as you hear, the tune is quite recognisable, in spite of the many transformations it has been through.

I now wish to show you a novel form of loud-speaking telephone receiver which was recently exhibited in London at the Institution of Electrical Engineers, by its inventors, Messrs. Alfred Johnsen and Knud Rahbek, two Danish Engineers, of Copenhagen. This instrument depends for its working, not on the varying attraction of an electromagnet on an armature as does the ordinary telephone receiver, but upon the varying co-efficient of friction that takes place between two rubbing surfaces under electrostatic attraction. Telephone receivers working by reason of electrostatic attraction are very old. When condensers consisting of alternate layers of tinfoil and mica were first constructed, it was found that if an intermittent high potential was applied to the leaves, the condenser could be made to hum. On this principle was based Dolbear's electrostatic telephone receiver, which consisted simply of two thin metal plates separated by means of a thin mica washer round their edges, so that the plates formed an air condenser. The back plate was prevented from vibrating by means of a screw pressed on it from the rear, while the front plate, which was held near the

ear, would vibrate under the force of the electrostatic attraction between the two. This instrument, when operated by a microphone transmitter connected with a step-up transformer so as to make the potential variations as high as possible, would repeat human speech, and it was found that if the two plates were initially polarised to a high potential the sounds produced were made louder.

A variation of this form of electrostatic receiver which I have found to work quite well for wireless signals, is to use two thin bare metal plates with a piece of chamois leather between them. The chamois leather is preferably glued over the surface of one of the plates, while the other is held to the ear, with the leather between them. If the two plates are now connected in the plate circuit of an amplifier all the louder signals can readily be heard, though, of course, the instrument is nothing like so sensitive or so loud as a well-made electromagnetic telehpone.

Nor is the employment of electrostatic attraction in conjunction with rubbing surfaces entirely novel for the purpose of producing a telephone receiver. As long ago as 1879, Mr. Conrad Cooke, lecturing in this room, showed an apparatus invented some years previously by the late Elisha Gray, of Chicago. This apparatus is illustrated in fig. 9, where, on the right, there is a microphonic telephone transmitter H sending undulatory currents from a battery MB through a step-up transformer, to line and earth. On the left-hand side of the figure there is an apparatus consisting of a circular hollow box D, which is mounted on an axle B upon a stand A, and can be rotated by the small handle B[1] The side of the box D away from the handle is closed with a lid of thin metal, the whole apparatus being connected to earth. To make it work, all that is necessary is for the handle to be turned so that the box rotates, and the operator, taking the line wire in his hand, should touch the thin lid of the box so that his finger rubs upon it as the box is rotated. It is then found that the varying electrostatic attraction between the rubbing finger and the rotating lid causes variations in the friction which throw the lid into vibration, so that sounds communicated to the microphone become audible, the hollow box acting as a resonator. I understand that Gray himself, at first thought that the effect was physiological and dependent upon living matter, but Tyndall, who investigated the subject, found that dead matter, such as pork rind, parchment, or leather, worked just as well as the human finger.

Then again, in the Proceedings for 1883 of the Institution of Electrical Engineers—or rather of the Society of Telegraph Engineers, as it was then called — I have found an account of what is called a static induction telephone invented by Mr. W. Moon. Fig. 10 is a reproduction of the instrument as depicted in Mr. Moon's communication And here is Mr. Moon's account of his apparatus in his own words:

"While experimenting with Dr. "Wright's tinfoil paper telephone, I "noticed that, when the two sheets of "paper were charged with high tension "electricity, they were attracted and "clung to each other, and that it re- "quired considerable force to pull them "apart. This fact suggested to me the "construction of the telephone I have "the honour of bringing before the "Society to-night.

"One sheet of tinfoil paper is fixed to

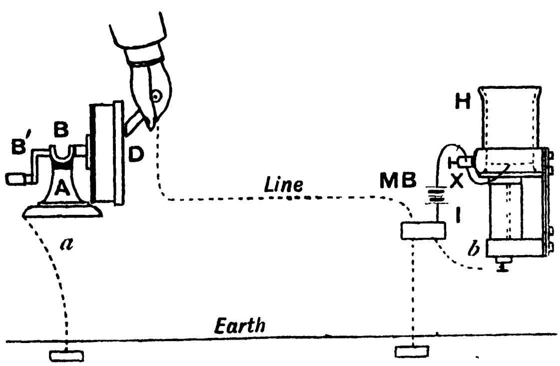

FIG. 9 ELISHA GRAY'S ELECTRO-STATIC TELEPHONE.

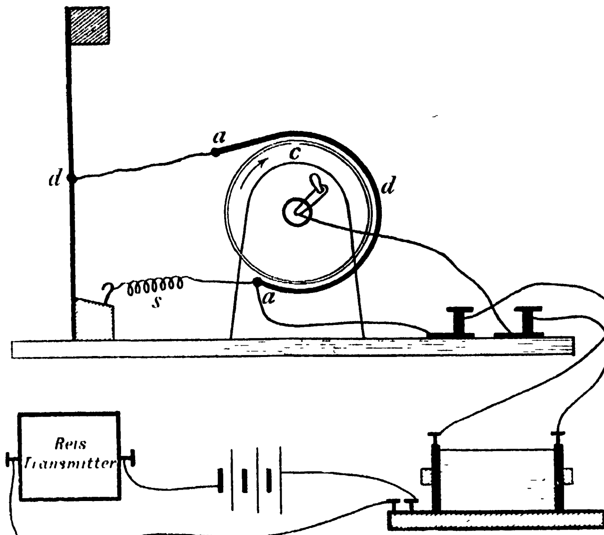

FIG 10 MOON'S STATIC INDUCTION TELEPHONE

"a cylinder, with the metal surface in- "side, and another sheet of similar paper "rests on the surface of the thus covered "cylinder, with its metal surface out- "wards, and is attached by a thin cord "to the centre of a diaphragm, so that, "on rotating the cylinder, the diaphragm "is pulled in the direction of rotation of "the cylinder by the friction between the "two surfaces of paper.

"By charging the two sheets of paper "with high tension electricity from an "induction coil, the friction is increased, "and the diaphragm drawn in at each "vibration of a rheotome, so that the "vibrations of the rheotome are exactly "reproduced in the telephone; and, by "substituting a Reis transmitter in the "primary circuit in place of the rheotome, "the pitch of each musical note of the "transmitter is exactly reproduced in the "telephone.

"The loudness of the telephone is pro- "portional to the surfaces of the paper "in contact, 'or to the capacity in farads,' "and most probably to the square of the "tension of the charge. It is, however, "necessary that the power of the in- "duction coil used should be proportional "to the capacity of the telephone, as, "if the coil is too powerful, sparking "takes place between the two surfaces "of the paper. With the larger tele- "phone on the table, I find that a coil of "¼-inch spark gives the best results.

"Mr. Kempe has improved the loudness "of the telephone by pressing the two "surfaces together by a spring, and also "by using powdered chalk between the "two surfaces of the paper.

"I have tried many different forms of "transmitters that Mr. Preece has kindly "supplied me with, and find that the "original form of Reis transmitter gives "the best result."

What Dr. Wright's tinfoil paper telephone was I have been unable to ascertain, though I imagine that tinfoil paper is merely paper and tinfoil glued together.

Elisha Gray's apparatus will be found described in text books; but I fancy that Mr. Moon's arrangement had been entirely forgotten until I accidentally unearthed it in looking through old numbers of the Proceedings of the Society of Telegraph Engineers for quite another purpose.

In connection with their apparatus, Messrs. Johnsen and Rahbek showed a very remarkable experiment which I hope to repeat. If you take a lithographic stone, which is not an insulator, but a very bad conductor, and glue on the back of it a piece of tinfoil, and then lay on the flat face of the stone a brass plate two or three inches in diameter, taking care that the surface of the stone and the surface of the plate are both quite flat so as to make good contact all over, it will be found that if the plate and the tinfoil respectively are connected up to a source of high potential, say

of several hundred volts, the amount of current that passes is exceedingly small, being, in fact, only one or two micro-amperes owing to the great resistance both in the stone itself and at the surface between the stone and the brass plate. Further, it will be found that while the fall of potential through the stone is comparatively small, a very large fall of potential—about 90 per cent. of the total—takes place between the two surfaces of the stone and the brass. Furthermore, whereas with no potential applied the brass plate can be easily rubbed about on the surface of the stone, when a potential say of 200 volts is applied the friction between the two becomes so great that it takes from three to five pounds pull to move the brass plate, the friction increasing and decreasing instantaneously as the potential is applied, or removed, or varied. As the total resistance is so great, very high resistances, as, for instance, the human body, can be inserted in the circuit without making any difference to the results.

The large pull required to move the brass plate when electrified can be shown by means of a spring balance, or, if the stone be inclined at a considerable angle with the brass plate electrified, the latter will stick wherever placed on the stone, sliding down immediately the moment electrification is removed.

hand-side of the figure will be observed a cylinder which is made of highly polished agate, into which a metallic core has been glued with water glass. Agate, like lithographic stone, is a very poor conductor of electricity, but conducts just sufficiently to allow any potential applied to the core to reach the surface of the cylinder, and also to leak away again when the potential is removed.

The agate cylinder is caused to rotate, and round it is stretched a thin metallic band one end of which is connected to a diaphragm M, the other end being kept taut by means of an elastic india rubber band marked S in the figure.

The tension on S and the extent to which the metallic band is wrapped round the cylinder, should be capable of adjustment. The left portion of the diagram shows how the apparatus is worked for the reproduction of speech from a microphone. T is the microphone supplied with current by a 2-cell battery and working through a 1 to 10 step-up transformer Tr; m is an adjustable shunt resistance across the primary of the transformer, by means of which the strength of the currents operating the transformer can be controlled. The secondary of the transformer is inserted between the filament and grid terminals of a thermionic valve,

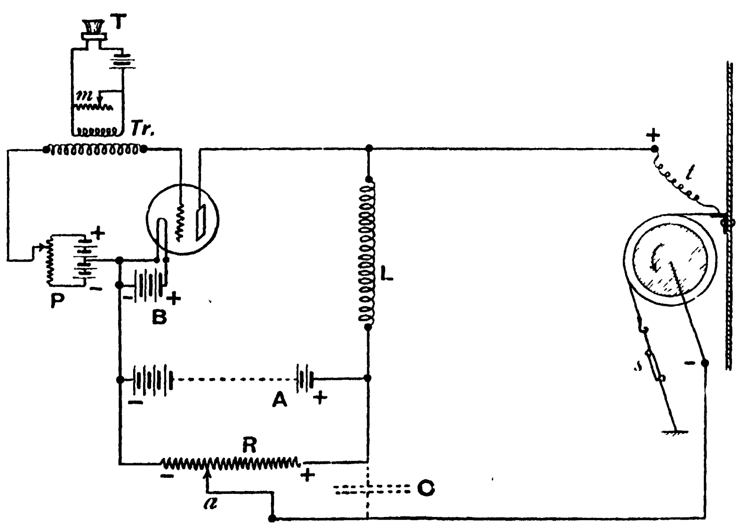

FIG. 11 JOHNSEN & RAHBEK'S TELEPHONE: DIAGRAM OF CONNECTIONS

Messrs. Johnsen and Rahbek have applied this principle to make a loud-speaking telephone which certainly gives remarkable results. Fig. 11 shows a diagram of the arrangement they employ. On the right-

connection being made to the grid through a potentiometer and battery P, whereby the grid voltage can be regulated. A battery A, of not less than 150 volts, is employed to supply the plate current, the voltage

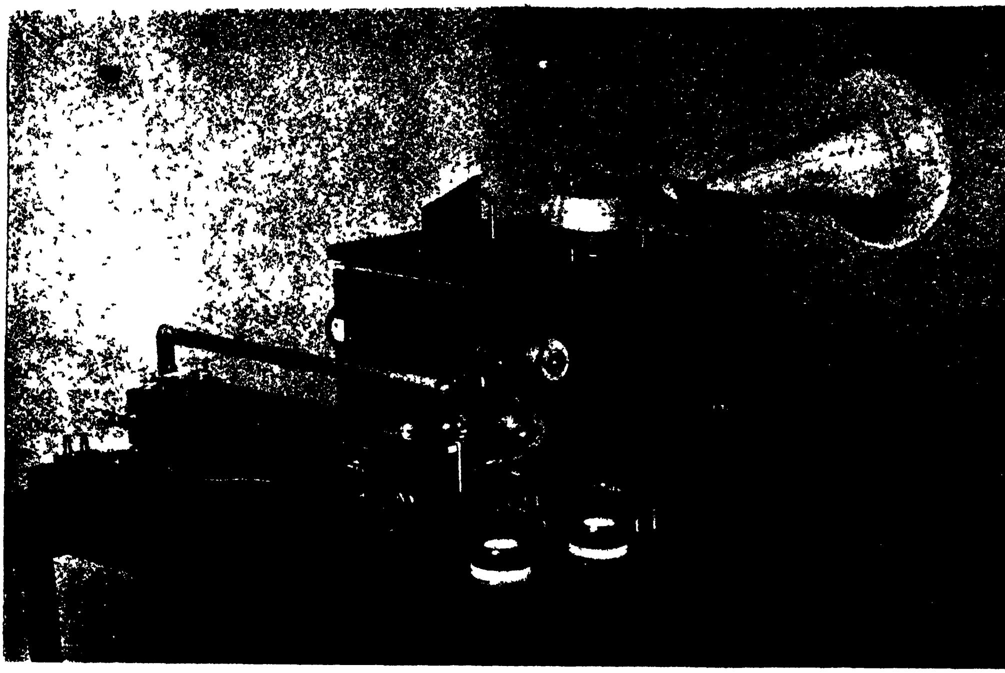

FIG. 12 JOHNSEN & RAHBEK'S TELEPHONE: GENERAL VIEW

actually applied being regulated by the adjustable high resistance R. Provided the resistance R is less than about 20,000 ohms, the condenser C shown in dotted lines, can be omitted. L is a self-induction choke coil of from 3 to 10 henries, through which the continuous battery current can pass, but which offers great impedance to the rapidly varying speech currents. By this means the metallic band is kept permanently at a high positive potential above the agate cylinder. Fig. 12 shows an apparatus constructed on this principle which has been put together in my laboratory. The agate cylinder, which is mounted on a vertical axis, is seen at the top, and is about two inches in diameter and about two inches long. The metallic band, which is nearly as wide as the cylinder, in this case is made of thin nickled copper, with the nickled side in contact with the agate. Messrs. Johnsen & Rahbek, who kindly supplied me with this nickled band, tell me that the best material for the band is rustless steel 0.02 m.m. in thickness. So far, I have not been able to obtain such thin rustless steel. Its advantage is that it does not wear out, whereas, after a few hours work, the nickel is worn away. The metallic band is connected at one end to an india-rubber band which, at its other extremity, is adjustable, and at the other end to the centre of an ordinary gramophone diaphragm at the end of a trumpet. The agate cylinder is caused to rotate in the direction that causes the metallic band to pull on the diaphragm, at about 100 revolutions per minute, by a small electric motor contained in the box below the cylinder, which latter it drives through belt gear. The adjustable resistance on the side of the box is for regulating the speed of the motor, while the long adjustable resistance on the left-hand side of the figure, is the high resistance R of the diagram, in this case having a maximum resistance of 10,000 ohms. In the middle of the illustration, near the bottom, are the thermionic valve with its adjustable filament resistance, and the choke self-induction. We have dispensed with the potentiometer, as we did not find this of much advantage. For the 150 volt battery A of the diagram, we use 200 volt continuous current from the supply mains.

We will now put the apparatus to work, and, as you will see, when I talk into this microphone which I hold in my hand, the instrument reproduces what I say very much louder than my own voice. For the reproduction of wireless signals or speech, all that is necessary is to connect up the plate circuit of the receiving amplifier with the

primary of the telephone transformer. As you will observe, when this is done, and signals are received, the results are startling.

I now propose to explain to you a method by means of which anyone who possesses a wireless receiving set can obtain the correct time accurately to the one-hundredth of a second.

As you will observe it is now nearly eight minutes past nine, at which time precisely the Eiffel Tower in Paris commences to send out a series of 300 dots, regularly spaced, at intervals which are 1/50 of a second less than one second. In each series the 60th, 120th, 180th and 240th dots are suppressed in order to facilitate counting.

Mr. F. Hope-Jones, of the Synchronome Co., Ltd., has kindly lent me a pendulum clock which beats seconds, for comparison with the dots. As you hear, the dots have now commenced, and as the intervals between them are rather less than one second the dots are gaining on the second-beating clock, and from time to time you will find that the dots and the clock beats coincide.

The method of using these dots for the purpose of getting the correct time is known as the Method of Coincidences, and constitutes an acoustic vernier. The observer listens to these dots in his receiving telephones, and listens also to the beats of his own second-beating clock which he is checking. By noting the time indicated by his clock at the moment of coincidence, as well as the number of the dot at which the coincidence occurs, it is easy to calculate the error of his clock to the one-hundredth of a second. For this purpose, it is necessary to obtain from Paris the exact times at which the first and the last dots were sent out. These times used to be sent out by wireless from the Eiffel Tower in Morse alphabet, but I understand they are no longer sent out, but can be obtained by those interested on application to the Eiffel Tower wireless station.

As already mentioned, the comparison is made by listening simultaneously to the wireless dots and the clock beats, and noting at which dot (i.e., as numbered from the beginning) close coincidence occurs. It is clear that, as the clock beats are spaced one second apart, and the wireless dots about 1/50 of a second closer together, there will be four or five opportunities to observe coincidences. At each coincidence the time shown by the clock to be checked is noted. As an example, suppose that the 45th dot occurs exactly when the clock to be checked shows 10hrs. 31mins. 2 secs. We first calculate the interval between dots from the figures obtained from Paris.

Assuming that the first dot occurred at 10hrs 30 mins. 10.27 secs., and the last (300th) dot at 10hrs. 35mins. 3.42 secs.

We then proceed as follows:—

	Hrs.	Min.	Secs.
Time of first dot	10	30	10.27
Time of 300th dot ..	10	35	3.42
Therefore, time of 299 intervals		4	53.15
Therefore, time of 1 interval			0.980
At first coincidence 45th dot (44 intervals) clock shows	10	31	2.00
Now, 44 intervals occupy 44 × 0.98			43.12
Hence, true time at 45th dot was	10	30	53.39
Instead of, as given by the clock	10	31	2
Hence clock error is .			8.61
			Secs. fast.

The above gives the error of the clock as compared with Greenwich mean time. If, now, a second check be taken, say, 24 hours later, the exact gaining or losing rate of the clock may be found with extreme accuracy.

Putting the above procedure in few words, it may be expressed as follows:

(1) Subtract the time of the first dot (as given by Paris) from the time of the last.

(2) Divide the difference so found by 299 (this would give closely the figures 0.98 secs., which is the interval between dots).

(3) Multiply this interval by the number of intervals between the first dot and that one at which coincidence was observed.

(4) Add this product to the time of the first dot. This gives the true time at the moment of coincidence.

It may be thought that this method of obtaining correct time to the one-hundredth of a second is an altogether unnecessary refinement of accuracy, but it is of the greatest value where there is any question of an erroneous determination of longitude, and it altogether eliminates the most troublesome factor ever present in observatories, namely, the personal equation of the observer who takes transits every night from the clock stars.

I think it now only remains for me to thank the various people who have assisted me this evening. My special thanks are

due to Mr. W. W. Burnham, of Deptford, who sent these really fine musical transmissions from Lewisham, and to Mr. Frank Phillips, who has so skilfully worked the receiving apparatus. Then I wish to thank also Messrs. Johnsen & Rahbek, of Copenhagen, who have given me very useful information with regard to the making and operation of their apparatus; Sir Herbert Jackson, who has taken endless pains in procuring for me an agate cylinder; Mr. S. G. Brown, who has lent me a special differential microphone transmitter, and also a loud-speaking telephone; Mr. R. C. Clinker, of Rugby, whose ingenious model in explanation of the working of the frame aerial I have shown you; Mr. Basil Davis, who has lent the fine example of the 'Magnavox'' loud-speaking instrument, and Mr. Hope-Jones, of the Synchronome Co., Ltd., who sent us that excellent specimen of the second-ticking clock. I wish also to thank my own assistants: Mr. Sidney Langley, who has made a large amount of the apparatus shown, and particularly the frame aerial, the six-valve amplifier and the loud speaker with the agate cylinder, and who has devoted an enormous amount of trouble to getting all this apparatus to work; and my secretary, Mr. A. W. Langley, who has also spent much time on the same business. I have also to thank Mr. Bradshaw, whose wirelessly transmitted voice you heard on the phonograph, the lady whom you by wireless heard singing in Victoria Street, and Mr. Davenport, who always presides so skilfully at the lantern on these occasions.

DISCUSSION.

Sir Oliver Lodge, D.Sc., F.R.S., in proposing a hearty vote of thanks to Mr. Campbell Swinton, for his address, said it was evident that an immense amount of trouble had been taken in preparing the experiments that had just been seen and heard. He thought the Chairman assumed a great deal of knowledge on the part of those present. It was evidently not the first time that he had addressed them on the subject of wireless telegraphy, and they had now seen some of the latest developments, but it was well to remember the extraordinary character of the demonstrations. It sounded as though the Chairman had got a gramophone under the table and was deceiving his audience, but it must be remembered that all the disturbances had come through the ether and had been reproduced by means of little lamps. It was not obvious, but it was true, that those little lamps had been doing the most essential part of the work. There the electron was harnessed, and the hot wire which was in the lamp was not for the purpose of giving light but for the purpose of supplying electrons, which evaporated from the hot wire. In that vacuum bulb there were a lot of electrons which were docile and obedient to every impulse which was given to them, and they were so quick in response that they could follow every fluctuation of the human voice. In fact, an interval of a thousandth part of a second was, as it were, a month to them; they could do all manner of things in that time. They had not the slightest difficulty in following everything, and if anyone had put one of the lamps out the whole demonstration would have stopped. The use of the magnifying valves rendered possible extraordinary developments. The practice of the art of wireless telegraphy was advancing with extraordinary strides, and those who were working with those valves were enamoured of their work, for the valves were most remarkable things. He believed that a great future which was as yet hardly realised, was before the method that made use of them, for they could be made to magnify a million times. By another kind of device a shouting telephone of greater power than those used before had become feasible, and already a voice could be magnified into an abominable noise as they had heard that evening! — and what [illegible] happen when sounds were magnified a [illegible] times he really did not know. No one [illegible] tell what the result would be when one b[illegible] to harness electrons in such a way as really to tap the energy of the atoms of matter. The present occasion was the first time he had heard the electrostatic telephone to anything like the extent that had been demonstrated by the Chairman. It was electrostatic attraction that was doing it. He doubted whether there was any need for a current at all. The reason the force was so great was because the two surfaces were so exceedingly close together. If one reckoned what the force was when one had 200 volts at a distance of about 1/1,000,000 mm., over a fair area, one would see it was a very great force. It was, as the Chairman had said, several pounds—it might even be several hundredweights. Perhaps one of the most remarkable things was the detection in that room of messages from Paris or Nantes or any other distant place upon a frame of the size of that exhibited by the Chairman. Generally an aerial station was a large erection with aerials exposed high up and collecting the waves. No such arrangement had been used on the present occasion. There had been just the frame shut up in a building in the middle of London. Moreover, the Chairman had previously carried out a most interesting experiment with the apparatus he had shown. He put it into a copper box to screen it off, and put the lid on, and still it could be heard. A copper plate was known to be completely

opaque to short-waves, but whether it would be completely opaque to the magnetic aspect of the very long waves that came from the Eiffel Tower, he (the speaker) was uncertain, and therefore he had followed the experiment with considerable interest. He (Sir Oliver) had made the same sort of experiment a long time ago, in the nineties, with Hertz waves of a few yards long; but now waves were being dealt with that were thousands of yards long and they might be able to get through. It seemed, at first, as though they were getting through, even when the lid was on, but if the lid was soldered on or the box made in some way absolutely wave tight, then they were stopped. Therefore, it appeared that the copper box was really opaque and yet the thing was so sensitive that the sound could be heard even when the whole of the apparatus was shut up in a box that only had the narrowest chink open. Somehow even large waves got in through the chink and produced the effect, though there were other experiments, waiting to be done, before complete opacity could be concluded. He wished in conclusion, to call attention to the large amount of work that had been carried out by the Chairman and the skill that had been shown in doing the experiments.

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., in seconding the vote of thanks, said he had known the Chairman for a very long time and had seen him carry out very many experiments during the last thirty years. One of his chief characteristics was that he took a great deal of interest in other people's work and added to it his own work. He agreed with Sir Oliver Lodge, that the experimental work shown by the Chairman that evening was of very high quality indeed, and it was impossible to thank him enough for the trouble he had taken. The members of the Society also owed the Chairman a deep debt of gratitude for the trouble he had taken and the success he had achieved in placing their old and important Society in a greatly improved financial position. It was due to Mr. Campbell Swinton that during his chairmanship a Committee was formed which went into the question of securing more funds. Personally he wished to thank the Chairman most heartily and he was sure all the members would join him in that for his efforts on behalf of the Society. It would have been a great pity if the Society had had to leave this historic building, and that occurrence had been rather imminent at one time. The danger had now been averted, and the Society could continue in its old rooms, in which so many distinguished and original lectures had been delivered for over 150 years.

THE CHAIRMAN, in returning thanks, said he wished to point out that, although he might have taken some little part in helping the finances of the Society by subscribing himself and by inducing other people to give subscriptions, the individual to whom most thanks were really due was the Secretary, Mr. Menzies. Mr. Menzies had personally found the very generous benefactor who had given the Society £30,000, and he, the Chairman, had no part in that.

The meeting then terminated.

DRAWN WORK, EMBROIDERY AND LACE INDUSTRIES AT SWATOW.

The drawn-work industry was introduced into Swatow by missionaries 30 or 40 years ago. At first the making of drawn work was taught to converts as a means of earning a livelihood, but the work soon came to be produced on a commercial scale. During recent years, writes the U.S. Consul at Swatow, the demand has fallen off, partly as a result of the war, but as new designs are being adopted it is again attracting more notice. However, in the opinion some persons interested in the business, this industry will never grow to be of great importance.

The centres of production is the Kityang district, and the number of workers is now estimated at 10,000. Although it is a household industry, the workers devote their whole time to it except during the harvesting of the rice crop.

Business is usually carried on in this way: A head worker or contractor will visit Swatow to buy material on his own account and then return to his village, where he distributes the material to workers, and at the same time settles the production price per piece with them. When completed he collects the work and takes it to Swatow for sale. More often he secures contracts from Swatow firms, in which case he is supplied with the cloth. Swatow firms buy or order from these contractors, and the goods are then sent to Hongkong or Shanghai for sale. A small retail business and some export abroad are done locally.

Grass cloth, Canton and Kityang, and some Shantung pongee have been until recently the only cloths used, but latterly Irish linen has been introduced. Prices are always on the piece basis. The most fashionable design is the "filet drawn," that is, an imitation of the filet lace pattern worked and drawn on the cloth. Another design for which there seems to be much promise is "mosaic," which was introduced, it is claimed, from Japan. There are about 1,000 workers engaged in this type of work. All drawn-work pieces are also embroidered.

White embroidery is of later origin than drawn work, having been produced commercially in Swatow only about 20 years. The seat of this industry is Chaochowfu, which for

many generations was noted for its embroidering of mandarin robes and theatrical dresses. There is now no demand for such work and the white embroidery has largely taken its place. However, embroidered scrolls and temple drapery are still being made. It is estimated that there are no less than 10,000 workers.

Unlike the drawn-work industry, there is an embroidery union, which includes about 20 shops Beside these, there are five or six open shops. This is a union not of the workers but of the shops, for the purpose of discouraging outsiders from engaging in the business The designing is done by men in the shops, but the cloth to be embroidered is distributed among the workers in their homes These union shops control more or less the scale of wages of workers as well as the price to be charged Swatow firms. These shops do business only on order, and receive the material from the firm placing the order.

This industry seems to have a bright future, and attempts to introduce new designs are being made with some success. Owing to the demand local prices for embroidery have advanced about 20 per cent. In comparison with the embroidery of Europe, the Philippine Islands, or Canton, Swatow work is said to be inferior, but the attention now being given to the industry will doubtless result in its improvement.

The filet lace industry was started in the Swatow district about four years ago and in 1918 the output had reached commercial proportions, but the rise in silver exchange in 1919 brought production to a standstill, and it has never since revived.

Filet lace is made in two parts, namely, the net and the working of the design. Chaoyang district is the centre of the net-making industry, and it is claimed that as many as 6,000 persons were engaged at one time in that work. For the design, Kityang has been the principal seat of the work. The thread used in this industry is British.

It seems that the crochet industry was introduced by missionaries prior to the drawn-work industry, but later it practically disappeared. The demand for this lace in 1919 effected its revival, and the number of workers is now conservatively estimated to be 5,000. Iam-tsau, a village in the Chenghai district, is the most important centre. Others of less importance are Ampo, Tangleng, Phu Sua, and Ungkung.

The industry is conducted in much the same way as the drawn-work industry. Head workers come to Swatow to receive orders for goods and to obtain thread, and when they return they distribute these materials among the workers. A head worker can effectively control about 200 workers These head women get the difference between what they receive for the work at Swatow and what they pay the workers. Their profits are said to be very handsome.

Only hand labour is employed in these industries, no machinery whatever being used. A drawn-worker's outfit consists of a pair of scissors, a needle, a thimble, and a circular frame or stretcher. The embroiderer uses a needle and a square frame. It is estimated that the value of the total production of drawn work and embroidery (including the cost of the cloth) in the Swatow district in 1919 was between £30,000 and £40,000

TAR, ROSIN AND TURPENTINE PRODUCTION IN FINLAND.

The tar industry in Finland is very old and was formerly of considerable importance, but the present production is comparatively small, amounting to about 50,000 hectolitres (40,000 barrels) per annum Of this amount, about 30,000 barrels are produced in factories and the remainder, in kilns, or charring stacks.

The rosin industry, on the other hand, writes the United States Consul at Helsingfors, is quite new. The first rosin factory was built in Finland by the Finska Kemiska A. B. only 10 years ago. Stumps were used as raw material and treated by a special method invented by the founder of this factory. There are now three rosin factories in the country. Three of the paper mills also manufacture fluid rosin for the manufacture of soap.

There are about 40 turpentine distilleries in Finland. All of them are small, as the raw material cannot be transported far. The Finnish distilleries can generally char from 3,000 to 4,000 cubic metres (cubic metre = 1.307 cubic yards) annually The largest is that owned by the A.B Tjarindustri and is situated in Suolahti. About 9,000 cubic metres of stumps are charred there each year. Among the other larger distilleries are the factory in Keuru, E. Math. Bonn's factory in Kolho, and a distillery in Multia, recently built by the A. B. Rafso Angsag The total annual production of turpentine is estimated at about 1,000,000 kilos (kilo = 2 2 pounds), of which about 800,000 kilos are produced in dry distilleries, about 100,000 kilos in rosin factories, and about 100,000 kilos as a by-product in sulphate cellulose mills. About 40,000 cubic metres of charcoal are produced in the dry distilleries and somewhat more than that in the kilns.

The total value of the annual production of tar, rosin, and turpentine in Finland is at present about 18,000,000 to 20,000,000 marks (Finnish mark = about 1d. at present exchange).

About 70 per cent. of the factories belong to Finland's Tjar-och Terpentinkontorslag, a union which was formed about 10 years ago for the sale of their products. It is probable, adds the Consul, that all the factories will soon join this union.

IMPROVEMENT IN METHOD OF PLANTING CASSAVA.

Mr. A. B. Carr, a director of the Agricultural Society of Trinidad and a prominent estate owner, has furnished the United States Consul in Trinidad with the following note as to a method he has discovered of shortening, by about one-half, the time required for the ripening of cassava tubers :

"Hitherto the way of planting the cassava was in short portions of the stalk, measuring from six to nine inches long; but purely by an accident it has been found that when the whole length of stalk of a cassava plant is planted the tubers ripen and are fit to eat in 4½ months, against the old method which involves at least 8 months The manner of planting is simply to insert the lower end of the stalk into the ground not more than two or three inches deep; and in order to secure the growing plant against the force of the wind, if in an exposed position, the plant should be tied to a stake. Planting is usually done in the month of May. In new lands as much as 12 to 15 tons of fresh tubers can be obtained, whereas in old, partially worn-out lands, unless a liberal supply of manure is allowed, not more than six to eight tons of tubers can be depended on"

This, says the Consul, should have great importance in practically doubling the cassava turnover from estates growing it

Concerning the uses of cassava in Trinidad, Mr. Carr writes :

"1 It is eaten as a vegetable, boiled in plain water

"2. It is made into what is known as farine, which is a coarse form of meal.

"3 After expressing the juice, the dry tuber is grafted into a meal, which upon being exposed to heat on a flat iron plate is made into bread

"4. The expressed juice is boiled down and certain condiments are added, thus producing casareep, which is the foundation of many good sauces.

"5. Starch is also made from the tuber, the method of manufacture consisting simply of allowing the expressed juice to settle, the heavy matter being precipitated and when dried forming the starch of commerce

It is known that alcohol can be produced from the cassava, which also contains sugar If the price of sugar remains abnormal for a lengthy period of time it is likely that scientists will turn their attention to the sugar contents of this tuber."

The cassava sauce known as casareep appears to have preservative as well as flavouring qualities and is an indispensable ingredient in the well-known West Indian dish, "pepper pot," which is especially popular in British Guiana, where casareep is manufactured in commercial quantities.

In connection with the industrial use of the cassava plant for the manufacture of alcohol, it may be mentioned that an Englishman was recently in Trinidad and British Guiana, investigating districts most suitable for cassava growing, and it is understood that in British Guiana about 10,000 acres of land were purchased for such purpose on behalf of distillery interests in Scotland. It is reported that large areas of cassava land in Madagascar and in Brazil have also been purchased for the same interests.

NOTES ON BOOKS.

THE HUMAN FACTOR IN BUSINESS By B. Seebohm Rowntree. London : Longmans, Green and Co 1921. 6s net

In the introduction and throughout, the author makes frequent reference to "the workers"; and from the context it appears that he really means wage-takers, as distinguished from capitalists, employers, salaried persons, and the remainder of mankind His opinion of "the workers" appears to be rather low. For example, he complains of the workers as "unfamiliar with the intricacies of finance and the economics of industry" (p. vi), and he, in an evident spirit of altruism, regards it as his duty to point out to "the workers" and others a way of realising a high ideal of comfort and prosperity

It is to be noticed that Mr Rowntree not only complains of "the workers" but also declares himself "profoundly dissatisfied with industrial conditions as they are to-day" (p viii), and the present book is an exposition of his scheme of reform, which appears to be based on the liberal sentiment of paying "the workers" something over the minimum which they will accept, the excess wage being, may be, in cash or in facilities

The advantages of the proposed reform are explained or elucidated by an illustrative instance; and what is to happen when the illustrative instance has convinced the world? Our author affords a clue to his hopes by remarking "it is well to remember that much social legislation consists in making generally compulsory what voluntary experiment has shown to be desirable" (p viii)

The illustrative instance on which the author's argument is based, is, however, of such a nature as to be somewhat unconvincing; the factory taken as a basis for the argument produces fine comestibles and dietetic specialities, the marketing of which may be much facilitated not only by advertising in its ordinary aspect, but by attention being called to the works, and a general sentiment as to production having taken place in an atmosphere of health, liberality and philanthropy.

Under the heading, Medical Inspection of Applicants for Work (p. 69), there are hints as to the importance of food products being produced by a healthy staff as secured by the

rule that applicants for work shall be medically examined, but "the only exception to this, rule is in the building department" (p. 70). Surely all artificers should be as subject to the human factor as are the other wage takers; and indeed to any practicable or desirable health factor.

As far as we can see, Mr Rowntree's book, although interesting, readable and manifesting a kindly sentiment towards "the workers," does not present any new view of things to the student of Econonics, but it should serve to emphasise the need of caution in drawing general conclusions from special instances

Although Mr Rowntree appears to be quite free from bias towards any particular school of political economy, his evident aspiration toward a statutory establishment (p. viii) of conditions such as he pictures, shows how completely he is at issue with Adam Smith's contention that regulation of wages by law destroys ingenuity and industry.

Our impression is that if a student of political economy were asked to deal with the case presented by Mr. Rowntree, his view would be something like this Under publicity and clever management the wage fund (taking the wider view of the term) would rise rapidly to the enrichment both of the exemplar wage takers and proprietors; but with a partly corresponding deprivation in other factories. Voluntary imitation under statutory legislation would, *inter alia*, tend towards the reaction conditions touched on by Ricardo in Chapter V, and all the wages would fall to (or perhaps below) the "Natural Price" in Ricardo's sense of this term.

GENERAL NOTE.

VICTORIA AND ALBERT MUSEUM — Students of early Chinese pottery will be interested in a case that has recently been placed on exhibition in the Loan Court. A number of friends of the Museum have combined to lend from their collections over fifty specimens of *Chien* ware, so called from the province of Fu-chien where it originated The ware is covered with an intense black glaze showing bluish reflections. in which are generally developed brown markings, compared by the Chinese to hare's fur or the breast of a partridge. In certain other varieties the markings resemble tortoiseshell or drops of oil on water; in some the black has yielded place almost entirely to a rich "dead leaf" brown. The exhibit serves to emphasise the infinite variety of this type of glaze, and the vases and bowls of which it is composed display considerable diversity of shape. The majority are in the form of small tea-bowls, for Chinese and Japanese alike have found this dark brown glaze without a rival for enhancing the qualities of their tea. Most of the specimens in this case may be ascribed to the Sung dynasty (960-1279), though a single Japanese example in the shape of a 17th century German tankard is there to sound a warning note against the danger of indiscriminate early dating

MEETINGS OF SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 28 .. ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. (Cantor Lecture.) Mr. A. M. Hind, "Processes of Engraving and Etching." (Lecture I.)

Electrical Engineers, Institution of (N. Eastern Section), Armstrong College, Newcastle, 7.15 p.m. Dr. S. P. Smith, "Single and Three-Phase Commutator Motors, with Shunt and Series Characteristics."

Mechanical Engineers, Institution of (Yorkshire Branch), Y.M.C A., Albion Place, Leeds 7.30 p.m. Mr. J. G. Graves, "The World's Money System."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m Mr. S. J. Perry, "On the Relation between the Course of Wholesale Prices of Commodities and the Market Value of various classes of Securities."

Faraday Society, at the Chemical Society, Burlington House, W, 8 p.m. 1 Mr. J. N. Greenwood, "The Effect of Cold Work on Commercial Cadmium." 2 Messrs. J. N. Pring and E O. Ransome, "Reaction between Cathodic Hydrogen and Nitrogen at High Pressures." 3 Mr. F H Jeffery, "The Electrolysis of Aqueous Solutions of Alkaline Nitrites with a Lead Anode and an Electrometric Determination of the Constitution of the Complex Anion Formed." 4. Mr. T. C. Nugent, "An Inhibition Period in the Separation of an Emulsion" 5 Messrs. N. R. Dhar and N. N Mittra, "Induced Reactions and Negative Catalysis." 6 Dr S. Judd Lewis and Miss F M Wood will exhibit and describe "A New Adjustable Thermostat for all Temperatures between 0 and 100 deg. Cent."

Architectural Association, 34, Bedford Square, W C., 8 p m Mr. Nigel Playfair, "Stage Design."

TUESDAY, NOVEMBER 29 . Electrical Engineers, Institution of (N. Western Section), 17, Albert Square, Manchester, 7 p.m. Messrs. L. J. Steele and H. Martin, "The Cyc-arc Process of Automatic Electric Welding."

Civil Engineers, Institution of, Great George Street, S W, 5 30 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. C. M. Williamson, "Photography and Mechanics, Facts and Possibilities."

Anthropological Institute, at the Royal Society, Burlington House, W., 8 30 p.m. (Huxley Memorial Lecture.) Mr. H. Balfour, "The Archer's Bow in the Homeric Poems."

WEDNESDAY, NOVEMBER 30 .. ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Mr. Noel Heaton, "The Preservation of Stone."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. H. H. Elvin, "Some Causes of Industrial Unrest, and a Remedy."

United Service Institution, Whitehall, S.W., 2.30 p.m. Colonel M. Earle, "The Officers Training Corps."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p m. Prof. W. de la Mare, "The Reading of Fiction."

THURSDAY, DECEMBER 1 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C., 5.30 p.m. Captain G. de Havilland, "The Design of a Commercial Aeroplane."

Camera Club, 17, John Street, Adelphi, W.C., 8.15 p.m. Madame Yevonde, "Women in Photography."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Messrs. L. J. Steele and H. Martin, "The Cyc-Arc Process of Automatic Welding."

University of London, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Mr. W. Bateson, "Recent Advances in Genetics (Lecture V.)

Journal of the Royal Society of Arts.

No. 3,602. VOL. LXX.

FRIDAY, DECEMBER 2, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FUND FOR PURCHASING THE SOCIETY'S HOUSE.

The amount sought by the Council to secure the freehold of the Society's House and to renovate the premises, as stated in the appeal recently issued to the Fellows, is £50,000.

The following is the first list of subscriptions to the Fund:—

	£	s.
Anonymous	30,000	0
The Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S.	2,500	0
Lord Bearsted	1,000	0
Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.	1,000	0
The Earl of Iveagh, K.P., G.C.V.O., LL.D.	1,000	0
Lord Leverhulme	1,000	0
Alan A. Campbell Swinton, Esq., F.R.S.	1,000	0
Sir Charles Allom	500	0
Sir George T. Beilby, LL.D., F.R.S.	500	0
Lord Blyth	105	0
Charles William Dyson Perrins, Esq., J.P.	105	0
Ralph Brocklebank, Esq., J.P., D.L.	100	0
Viscount Hambleden	100	0
William John Leonard, Esq.	100	0
Gwyn Vaughan Morgan, Esq.	100	0
George Sutton, Esq.	100	0
Sir Henry Trueman Wood	100	0
Messrs. Coutts & Co.	52	10
Viscount Elveden, C.B., C.M.G., M.P.	50	0
Major Sir Humphrey Leggett, R.E., D.S.O.	50	0
The Hon. Richard Clere Parsons	50	0
H. Lewis Doulton, Esq.	25	0
Peter MacIntyre Evans, Esq. LL.D.	25	0
Frederick Lamplough, Esq.	25	0
Sir Charles Herbert Theophilus Metcalfe, Bt.	25	0
Sir Harry James Veitch	25	0
Sir Robert Usher, Bt.	21	0
The late Sir Shapoorji Broacha	20	0
Henry Bubb, Esq., J.P.	20	0
Lord Foley	20	0
Mrs. A. E. Llewellin	20	0
Carmichael Thomas, Esq.	20	0
John Augustus Voelcker, Esq., M.A., Ph.D., F.I.C.	20	0
In Memory of Richard Roberts	15	15
"R.P.S."	12	10
William Henry Flanagan, Esq.	10	10
Sir Claude Hamilton Archer Hill, K.C.S.I., C.I.E.	10	10
George William Macfarlane, Esq.	10	10
Captain W. N. McClean	10	10
Henry Morley, Esq.	10	10
Thomas Whitehead, Esq.	10	10
John Milne Barbour, Esq., M.A., J.P.	10	0
Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.	10	0
Byron Brenan, Esq., C.M.G.	10	0
L. J. Cadbury, Esq.	10	0
Alexander Ernest Carroll, Esq., Assoc.M.Inst.C.E.	10	0
Sir Valentine Chirol	10	0
Somers Clarke, Esq., F.S.A.	10	0
James Colquhoun, Esq.	10	0
Charles Gow, Esq	10	0
Walter Geoffrey Jackson, Esq.	10	0
Alexander Walker, Esq.	10	0
Sir Frank Baines, C.B.E., M.V.O.	5	5
Frederick Edward Eiloart, Esq.	5	5
Herbert Foot, Esq.	5	5
Thomas Muddiman, Esq.	5	5
Ashley Edward Oram, Esq.	5	5
Charles Henry Quittenton, Esq.	5	5
Mrs. E. R. Stephens	5	5
Henry Allan Steward, Esq.	5	5
Gilbert Christopher Vyle, Esq.	5	5
Arthur Edward Williams, Esq.	5	5
Commander Benjamin Whitehouse, R.N.	5	5

	£	s.
Lord Askwith, K.C.B., K.C., D.C.L.	5	0
Stéphane Barlot, Esq. ..	5	0
Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.	5	0
William Bennett, Esq., J.P. ..	5	0
Sir John Benton, K.C.I.E., M.Inst.C.E.	5	0
Sir Walter W. Berry, K.B.E. ..	5	0
George Corderoy, Esq.	5	0
James Filshill, Esq.	5	0
Mrs. Horace Gray	5	0
Donald Gunn, Esq.	5	0
Kenneth Phipson Hawksley, Esq., M.Inst.C.E.	5	0
C. R. Hugon, Esq.	5	0
Major-General Beresford Lovett, C.B., C.S.I.	5	0
John Wanklyn McConnel, Esq., M.A.	5	0
Lord Sanderson, G.C.B., K.C.M.G.	5	0
Mrs. Bernard Shaw	5	0
George Lawrence Stewart, Esq., M.A.	5	0
J. S. Taylor, Esq.	5	0
Luke Thornber, Esq.	5	0
Lieut.-Colonel Henry Edward Tyler, R.E.	5	0
George S. Watson, Esq... ..	5	0
Charles Herbert Moss, Esq. ..	3	3
Robert Thomson, Esq. ..	3	3
Edward John Bolton, Esq., A.M.I.Mech.E., M.Inst.Met. ..	3	0
Peter Abel, Esq...	2	2
Denis Ripley Broadbent, Esq., A.M.I.E.E., A.M.I.M.E. ..	2	2
Daniel Buckney, Esq.	2	2
Frank Christy	2	2
Professor Arthur William Crossley C.M.G., D.Sc., Ph.D., F.R.S...	2	2
Verney Drew, Esq.	2	2
Alfred Edward Hayes, Esq. ..	2	2
James Laird, Esq.	2	2
George Frederick Lake, Esq., L.R.I.B.A.	2	2
Ernest George Mardon, Esq. ..	2	2
Kendall Park, Esq.	2	2
Harvey B. Robarts, Esq., M.A.. F.R.G.S.	2	2
Thomas Tucker, Esq., F.C.S. ..	2	2
Captain Edward William Wakefield	2	2
Brig.-General A. C. Bailward ..	2	0
Charles W. Braine, Esq... ..	2	0
Louis S. Beale, Esq.	1	1
Thomas Bolas, Esq., F.C.S. ..	1	1
Edward Carpmael, Esq., B.A...	1	1
Walter Septimus Curtis, Esq., M.A.	1	1
Arnold Lupton, Esq.	1	1
Christopher Charles Powell, Esq.	1	1
Wilfrid Levison Randall, Esq. ..	1	1
Herbert Lushington Storey, Esq., J.P., D.L.	1	1
E. Howard Wilkins, Esq., ..	1	1
J. Melrose Arnot, Esq.	1	0
Colonel Alexander W. C. Bell ..	1	0
Henry A. Fleuss, Esq.	1	0
Johnson Hayward, Esq. ..	1	0
Geoffrey Appleby Longden, Esq.	1	0
Frederick T. Murdoch, Esq. ..	1	0
William Whitaker, Esq., B.A., F.R.S.	1	0
	£40,201	13

The above list includes all subscriptions received up to November 26th. Further lists will be published in the *Journal* from time to time.

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 5th, at 8 p.m. (Cantor Lecture.) ARTHUR M. HIND, O.B.E., M.A., Assistant-Keeper, Department of Prints and Drawings, British Museum, and Slade Professor of Fine Art in the University of Oxford, "Processes of Engraving and Etching." (Lecture II.)

TUESDAY, DECEMBER 6th, at 4.30 p.m. (Dominions and Colonies Section.) FREDERICK COATE WADE, B.A., K.C., Agent-General for British Columbia, "British Columbia—The Awakening of the Pacific." THE DUKE OF DEVONSHIRE, K.G., G.C.M.G., G.C.V.O., will preside.

WEDNESDAY, DECEMBER 7th, at 8 p.m. (Ordinary Meeting). EMILE CAMMAERTS, "Literature and International Relations." H.E. the Belgian Ambassador will preside.

FOURTH ORDINARY MEETING

WEDNESDAY, NOVEMBER 23rd; MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Anis, C. A. M., Calcutta, India.
Ellis, Alec R., Liverpool.
Keller, George J., Bloomsburg, Pa., U.S.A.

Kutar, Kekobad Rustomji, Bombay, India.
Lewis, Samuel Judd, D.Sc., F.I.C., Ph.C., London.
McCutcheon, Robert Thomson, F.S.A.A., F.C.W.A., Glasgow.

The following candidates were balloted for and duly elected Fellows of the Society:

Baillie, Andrew Francis, London.
Bliss, Ernest H., B.Sc., London.
Graham, Andrew MacIntyre, Liverpool.
Greaves, Richard Methuen, Portmadoc.
Morris, Squadron Leader A. S., O.B.E., R.A.F.
Rogers, Captain Archibald Clement Campbell, Tringganu, Federated Malay States.
Symington, Harry, London.

The Trueman Wood Lecture on "The Coming of Age of Long-Distance Wireless Telegraphy, and some of its Scientific Problems," was delivered by Professor John Ambrose Fleming, M.A., D.Sc., F.R.S.

The Lecture will be published in the *Journals* of December 9th and 16th.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

FRIDAY, NOVEMBER 25th; BRIG.-GENERAL LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., in the chair. A paper on "An Imperial Airship Service" was read by Mr. A. H. Ashbolt, Agent-General for Tasmania.

The paper and discussion will be published in the *Journal* of December 23rd.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 4th and 11th January, 1922, at 3 p.m., by Mr. William Reginald Ormandy, D.Sc., F.I.C., on "Clay: What it is—Where it comes from—and What can be done with it." The lectures will be illustrated with experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

THIRD ORDINARY MEETING.

WEDNESDAY, NOVEMBER 16th, 1921.

MR. BASIL OLIVER, F.R.I.B.A., in the Chair.

THE CHAIRMAN, in introducing Mr Lyon, the author of the paper, said that when he was honoured by an invitation to preside at the meeting he accepted it very gladly, because he knew Mr. Lyon's enthusiasm and the way he had nursed the youngest School of Architecture into a flourishing concern. He thought the Royal Society of Arts was to be congratulated on having chosen modern architecture for the subject of the paper; it was rather refreshing to find new work being considered, because old work was so frequently dealt with. Modern work was beginning to have more attention paid to it now. Professor Riley had been dealing with Liverpool architecture in a series of articles in the local press, and Mr Powys, who was present that afternoon, had been writing on the subject in the *London Mercury*, and there were many other signs that more interest was being taken in the matter. There was a general looking forward and rather less looking back.

The paper read was:—

MODERN BUILDINGS IN CAMBRIDGE AND THEIR ARCHITECTURE.

By T. H. LYON, M.A.,
Director of Design in the University School of Architecture, Cambridge.

It is difficult to fix a suitable period from which to begin a lecture on the Modern Architecture of Cambridge. The first breaking away from what may be termed "traditional Cambridge Architecture" took place in the Seventeenth Century, a breaking away which is represented by such buildings as the third court of St. John's College, the western half of St. Catharine's College, the whole of Clare College, excepting only the Master's Lodge, erected between 1705 and 1715, and the Chapel, erected between 1763 and 1768. Clare College was, however, according to Messrs. Atkinson and Clark, erected on more traditional Cambridge lines with pointed windows and battlements, which were altered to their present state probably in 1762. I find difficulty in accepting this statement as correct. Judging from the appearance of the building, I feel that the alterations then made must have included much more than the squaring of

FIG. 1.—GIBBS' BUILDING, KING'S COLLEGE.

FIG. 2.—UNIVERSITY LIBRARY.

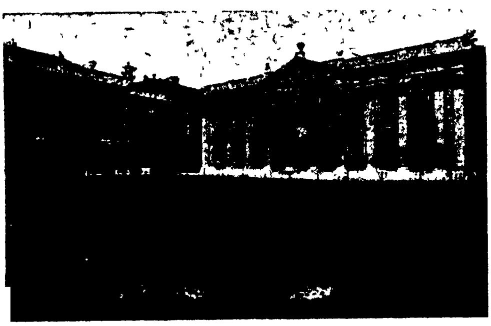

FIG. 3—SENATE HOUSE

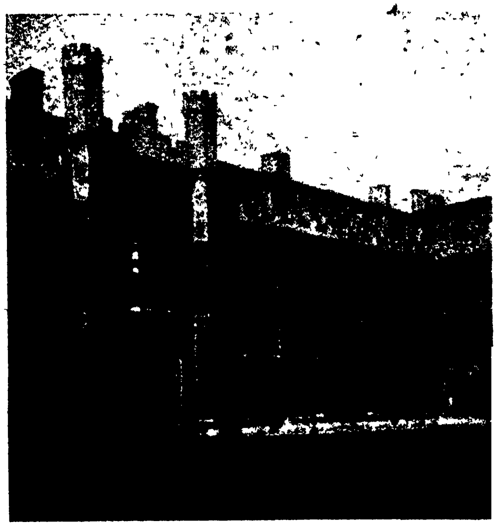

FIG. 4.—CORPUS CHRISTI COLLEGE.

FIG. 5.—BODLEY'S BUILDING, KING'S COLLEGE.

FIG. 6.—DOORWAY, ST. JOHN'S COLLEGE.

the windows and the substitution of balustrades for battlements.

The architects of the Eighteenth Century struck an entirely new note in their work, a note quite alien to that of traditional Cambridge architecture. And if we consider such buildings as that erected by Gibbs at King's College, the University Library and the Senate House, we cannot but be thankful to these architects for their deliberate break with tradition. Anyone who appreciates architecture will, I think, admit that more than half the architectural beauty of Cambridge is due to these Eighteenth Century buildings. Without them the King's Parade would be dull indeed.

But the work of the Eighteenth Century architects scarcely satisfied the more romantic cravings of the Nineteenth Century. Perhaps scholarship in architecture had to some extent become discredited, or, it may be, that the classical type in its modern garb was too modern to be of interest to the first antiquarian enthusiasts. And the antiquarians were beginning to rule the roost. Be this as it may, with the exception of the Fitzwilliam Museum, erected in 1837, and Downing College, erected between 1807 and 1873, there has been up to our day, and there still is, a harking back to a pre-Eighteenth Century period.

The work of the Eighteenth Century is, I am aware, wasteful from the point of view of the later Nineteenth and Twentieth Century requirements. The apartments in the Gibbs' Building at King's College, fit for the sons of noblemen, are extravagant in view of the requirements of the average undergraduate of to-day.

The problem which had to be faced in the Nineteenth Century, and which presses more than ever now, is that of obtaining the greatest possible accommodation on an ever restricting area.

The colleges of Cambridge are, with few exceptions, greatly in need of funds, whereas the number of students desiring University education increases year by year; and if we consider that a college of over 200 students has housing accommodation for only 40 within its walls, we do not wonder that the palatial buildings of the Eighteenth Century are out of favour.

We will begin our review of Cambridge Modern Architecture with the work of William Wilkins in the Nineteenth Century. William Wilkins was, I am convinced, at heart in sympathy with the classical tradition of the Eighteenth Century. The Gothic court at Corpus Christi College for instance, is in disposition after the classical manner. Reconstruct the windows and you have what might have been an admirable adaptation of Seventeenth and Eighteenth Century Architecture to Nineteenth Century requirements. The work is dull just because Gothic detail is applied to a building classical in its balance and proportions. The windows and doorways in the block against the street have a particularly disconsolate appearance, for they lack any sort of connection either one with the other or with the parent building. The whole is rather suggestive of a family quarrel.

Wilkins was a purist in detail; Gothic or Classic, he must have one or the other, and so he cannot let his fancy play as did the builders of Brasenose College, Oxford, where we have a fusion of the two traditions undoubtedly interesting and pleasing in its gaiety.

William Wilkins was also in spirit an artist; he cared above all things for the appearance of his buildings. He felt, as every artist must, that there is a dull monotony in the mere repetition of set after set of students' rooms, exactly of the same proportion and plan. And, therefore, he cared little for his interiors, so much so that he has even placed windows down at the floor level where to have raised them to the normal level would have upset the classical balance of his exterior.

Unlike the buildings by Rickman at St. John's College, once inside the living rooms of a Wilkins' building Gothic all but disappears, for his classical bias reasserts itself in doorways and mantelpieces, and he is Gothic only in the treatment of what is common to his exterior and interior, viz., in the stonework of his windows. The Rickman buildings at St. John's College were erected in 1825, and the Corpus New Court in 1822. In comparing these two buildings, we realise that Wilkins was a much greater artist than Rickman. Corpus Christi College was saved from an architectural disaster such as St. John's College suffered at the hands of Rickman. We may pass over the abomination of desolation which Trinity College suffers from, erected between 1859 and 1868, by Salvin, and known as Whewell's Court, with the remark that this building suggests the blank despair aroused by tragedy without one relieving touch of comedy.

Now the problem which the Nineteenth Century architects had to solve, and which I have mentioned, viz., that of obtaining greater accommodation on a restricted area, had been very successfully solved in the Seventeenth Century. I refer to the buildings erected at St. John's College in 1674, probably by a pupil of Sir Christopher Wren, and also to those erected in 1679 at St. Catharine's College. The tradition then created might have developed further and successfully under the hands of as skilful an architect as William Wilkins, had not the palatial conceptions of the Eighteenth Century tempted him, and rightly so, to adopt a more classical treatment in his planning, while probably, some outside influence forced him to adopt Gothic detail. I discovered a note at the bottom of several of the drawings made by Wilkins for the work at Corpus Christi which is worth quoting:—"The contractor is to produce a plaster cast for all the sculptured and carved work from some building, to be approved by the architect of the College before it is executed." This quotation scarcely suggests a keen interest in Gothic detail.

William Wilkins failed, as I have stated, in an endeavour to apply pure Gothic form to a classical disposition, and it will be useful at this point to compare his work with that erected at King's College in 1891 by the late Mr. Bodley. Mr. Bodley felt and understood Gothic architecture, and although his work is the work of Bodley, his buildings are Bodley-Gothic. At times he indulges in Gothic idiosyncracies, almost to the point of disaster. We may, I think, consider as an instance of this the way his corner tower arrangement, in the building I refer to, is very nearly cornered out of existence. His works give the impression that on the whole he loves order, but also that he sometimes feels in his Gothic enthusiasm a desire to fight against it. In his passion for grace and refinement he gives to his work, at times, almost a touch of prettiness; as witness his chapel at Queens' College, which has a suggestion of prettiness more appropriate to an Anglican sisterhood than a College Chapel. There is an absence of the "grand manner" in his work, which seems to make it somewhat out of place in Cambridge. The "grand manner" is, to some extent, evident in the work of Wilkins, however much we may abhor his Gothic treatment.

The architects of the Eighteenth Century planted this "grand manner" in Cambridge, and once there, all modern architecture which fails to uphold it does, to some extent, sink into insignificance. I do not believe that the secret of the "grand manner" is a question of bulk, for plenty of modern buildings in Cambridge are bulky enough and to spare, but I do believe that it lies in breadth and simplicity of general conception. It is evident that the most unimportant doorway may have a touch of the "grand manner," as witness the doorway with the portcullis and crown over it in the Second Court of St. John's College.

The main fault of Cambridge Modern Architecture lies in a failure to uphold the "grand manner." Probably, owing to the multiplication of windows and therefore the decrease in plain wall space, which resulted from the necessity of obtaining more and smaller students' rooms under one roof, the problem of upholding breadth and simplicity became a very difficult one to solve. If we compare the Senate House with the Gibbs' building at King's College, we shall, I think, realise that the slight overcrowding of the windows in the Senate House places it second to the Gibbs' building as an example of the "grand manner" in architecture. I need hardly mention that the best example of this "grand manner" in Cambridge is Sir Christopher Wren's Library at Trinity College. As the most woeful examples of its absence in more modern Cambridge Architecture I should name the new buildings at Trinity Hall, which, by the way, should be compared with the delightful additions to the Master's Lodge at that College; both, and it is almost unbelievable, designed by the same firm of architects; all the modern buildings at Queens' College, and, in fact, wherever the so-called traditional collegiate architecture has been sold to colleges by the yard. This type of architecture is entirely negative and without a spark of interest. Better the correct proportion of Essex's work at Trinity and St. John's, however dull, than this doll's house rubbish. One feels that the architects who erect such buildings can never have felt Cambridge proper; that they have visited Cambridge only under the auspices of some antiquarian society, the members of which consider even the "traditional idol" at King's College almost too modern for their serious con-

FIG. 7.—LIBRARY, TRINITY COLLEGE.

FIG. 8.—FITZWILLIAM MUSEUM.

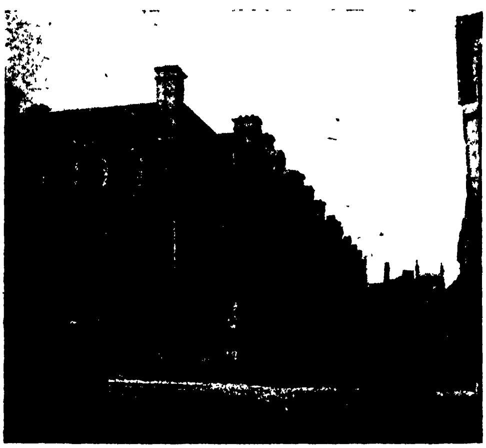

FIG. 9—SCOTT'S BUILDING, PEMBROKE COLLEGE.

FIG. 10.—MALTING HOUSE.

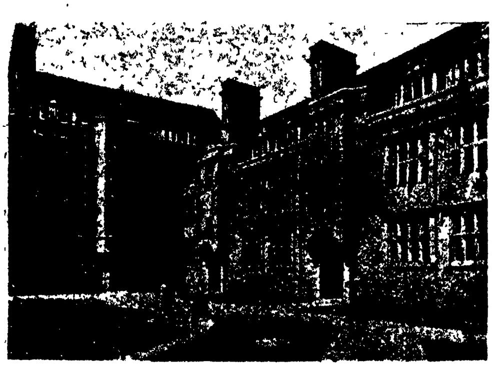

FIG. 11—NEW BUILDINGS, EMMANUEL COLLEGE.

FIG. 12.—NEW BUILDINGS, CHRIST'S COLLEGE.

sideration. The idea, which is yet, I believe, so prevalent, that Cambridge Architecture is just a delightful old-fashioned jumble of buildings, is quite an incorrect one for those who have eyes to behold. The architects of the Eighteenth Century continued the work of the master builders and architects of the Seventeenth, in giving a definite "lay out" to the University as a whole. We have only to note the compact arrangement of Clare College, the largeness of its conception and its completeness as a College, in order to view with horror this modern system of dotting buildings at all angles in the College grounds. A building in Cambridge succeeds as Cambridge Architecture only if it is dignified as a unit and at the same time gives further dignity to the College as a whole. This, then, is my main grievance against the architects of Modern Cambridge.

Now let me turn to modern buildings which appear to me to have that touch of the "grand manner" which is so essential to success in Cambridge Architecture.

Perhaps I should place in the first rank that most wonderfully beautiful building at Emmanuel College known as the "Founders" or "Westmoreland Building," rebuilt in 1811; Downing College, erected by William Wilkins (fellow of Gonville and Caius College, Architect) in 1807; the Fitzwilliam Museum, erected in 1837 by Basevi. The last I consider rather large in scale for Cambridge. It tends to crush the University Library and the Senate House, despite the fact that these two buildings are at some considerable distance from it. I think this will be felt by anyone who can carry scale in his eye. It is, however, delightful to walk slowly up the steps feeling the full dignity of this building, and while doing so an architect cannot but wonder whether the money will be forthcoming to provide a new University Library which shall not be insignicant in comparison with the Fitzwilliam Museum, or, indeed, with the front of the old library itself.

I find the "grand manner" in Scott the Younger's addition to Pembroke College, erected in 1883, and very much so in the addition to Sir Christopher Wren's Chapel at this College, made by Sir Gilbert Scott. The work of Scott the Younger suggests a carrying on of the tradition of the master builders as originated in Clare College. In viewing Scott's building, one feels that he did something not only for Pembroke College, but also for the University as a whole, that he had grasped the ideal for University Architecture set us by the builders of the Seventeenth and Eighteenth Centuries. And, moreover, he is original without the least touch of idiosyncrasy; he does not despise the old notes, he knows how to rearrange them so as to express his own striking individuality. If you desire to study the work of this genius nearer to hand than Cambridge, you have only to visit the Church of St. Agnes, Kensington, and, above all, that of All Hallows, at Southwark. He is as versatile in these churches, and he expresses himself as freely there as he does in his buildings at Pembroke College. He does not strive to invent new mouldings, a practice on the part of architects which has been disastrous to so many modern buildings. He contents himself in this respect with the accepted forms, as does a musician with the notes of the piano.

Just as Scott the Younger grasped the necessity for the "grand manner" in his Pembroke buildings, so also did Professor Prior in his laboratory almost opposite, and also Sir Thomas Jackson in his Law Library in the same street, although in this last instance the breadth of the general conception is almost frittered away by insignificant detail. For instance, for my own part, I feel that the columns which are applied to the ground storey cut up the base of the building and destroy its scale. The long bays in this front are admirable and give great dignity to the whole block.

There is perhaps no architecture in Cambridge which we regret more than that of Mr. Alfred Waterhouse, although as sound careful building it is beyond praise. Mr. Waterhouse must have been indeed an architect with whom no builder dared trifle. It is sad that so much good building should fail so completely from the æsthetic standpoint. His work is full of thought, but with almost an entire absence of æsthetic feeling. It is of interest to note the influence of French Architecture upon Mr. Waterhouse, apparent in the front of Pembroke College, facing Trumpington Street, and here his hand is less heavy than in his building at Gonville and Caius College. The tower to this latter building is little short of a monstrosity. It crushes the Senate House and the University Library, and might well be considered a public nuisance which the authorities of

Gonville and Caius should be asked to remove. I am well aware that the architecture of every man of note is of interest, and also that Cambridge will, because the work of so many important architects is represented in its modern architecture, become a town much visited by future architects for the purpose of studying work of the Nineteenth and Twentieth Centuries; nevertheless, too big a price may be paid in the cause of interest, and I believe that the tower which I have vigorously condemned does so much damage to the architectural effect of the King's Parade that it should not be spared simply because it is the work of Mr. Waterhouse.

While we are, in imagination, on the King's Parade, I want to draw your attention to the range of buildings belonging to King's College and facing Trumpington Street which were added to the Wilkins building by Sir Gilbert Scott in 1870. We have here a very clever handling of what might perhaps be called Wilkins' Gothic. I feel that Sir Gilbert Scott has given to the Wilkins style just that unity between mass and detail which Wilkins in his work at King's College failed so conspicuously to obtain. As neo-Gothic this building is admirable for its date. It may lack the grace of Mr. Bodley's Gothic building in this College, but it has more substance, a greater sense of strength, and is more definitely an architectural composition. It is, I feel, much nearer in character to the work of the late Mr. Pearson than to that of Mr. Bodley.

The new range in Sidney Sussex College, by the late Mr. Pearson, does seem to me to be lacking in grace. The depressed arches to the cloister, the over-mullioned windows and the way feature elbows-out feature do together produce an effect which is architecturally ungraceful. At the extreme, Mr. Bodley is perhaps over-refined and Mr. Pearson somewhat coarse. As instance of this I would cite Mr. Bodley's Chapel at Queens' College and the building by Mr. Pearson which we have just been considering. Perhaps graceful architecture has just that touch of "damned nonsense" about it which escapes the effeminate; in other words, it has the "grand manner" which characterises a personage of unmistakably high breeding. A very good example of what I mean by grace in architecture is the "Malting-House," which is the work of Mr. Dunbar Smith and and the late Mr. C. C. Brewer. This building is also an example of the "grand manner" as it applies to quite a small building. The "grand manner" has, as I have stated, little to do with the largeness or the importance of a building, it depends for its existence far more upon the relationship between the components and the whole. And I think it is just because this relationship between the components and the whole is somewhat lacking in the new buildings at Emmanuel College that they fail to impress us as they should. There can be no denying that many of the features in this building, when considered apart from the whole, are both graceful and charming, but they fail to enhance the general effect. It may be that the lack of co-ordination is largely due to the architect's use of small rubble for his interstices. The effect is rather as in writing, where we are bothered by too many full stops owing to the shortness of the sentences. Without in any sense wishing to detract from the appreciation justly due to this original and charming addition to Cambridge Architecture, I must point it out as an example of the use of invented moulding, which I have taken the liberty of condemning earlier in this lecture. I note, in this building, the influence of the supreme destroyer of all classical feeling in moulded work. The building has been given thereby a touch of affectation which is alien to the general conception of the architect.

The lack of co-ordination, which means the absence of the "grand manner," is often due to the architect's hesitation in his design between a vertical and a horizontal treatment. This hesitation is well exemplified in the new building in the third Court of Christ's College, and the loss produced thereby becomes apparent if we compare this building with the Gibbs' building at King's College. Notice the dignity given to the King's building by a perfect balance between the horizontal and the vertical treatment, and then note the lack of dignity produced by the hesitation between these two treatments, conspicuous in the Christ's building.

There is a sense of the inevitable, of a decision taken and uncompromisingly expressed, which marks architecture after the "grand manner." And, what is far from being true in fact, a sense of the easily accomplished, a sense that anyone could have done the same; just as the manners of the highly bred appear so simple and so

Fig 13.—Henry Martyn Hall

Fig 14.—Gateway, New Buildings, Emmanuel College

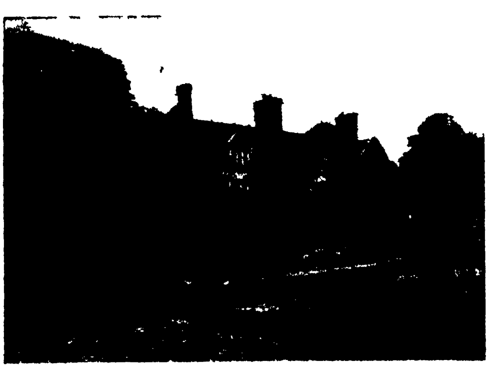

Fig 15.—New Buildings, Magdalene College.

Fig. 16.—Engineering Buildings, Coe Fen

Fig 17.—National Institute of Agricultural Botany

Fig 18.—Chapel, Sidney Sussex College.
T. H. Lyon, Architect.

facile, when in reality they are the result of a highly complex organisation composed of subtleties which are foreign to other than the genuine article. It is the "grand manner" which marks the work of a real genius.

We have, I think, in Cambridge, three definite types of modern architecture. We have architecture which is after the "grand manner," architecture which expresses the picturesque, and architecture which is wholly negative in character. I have named the buildings which seem to me to uphold the "grand manner," and of buildings which are successful examples of the picturesque I would mention the Henry Martyn Hall, erected by Professor Prior in 1887 as being in the first rank. This building might perhaps be considered as picturesque after the style of the "grand manner," for it has very much more dignity than generally falls to the lot of picturesque architecture. The same may be said of the entrance to the new buildings at Emmanuel. This entrance seems to want but a touch to bring it altogether on to the side of the "grand manner." The picturesque touch is, I believe, due to the use of rubble filling and also to the character of the hood moulding.

The carving over this doorway by the late Mr. Broadbent, who also executed the plaster ceiling in Sidney Sussex Chapel, is very delicate and beautiful. It is almost over delicate for exterior work in this country with its smoke-laden atmosphere. The new buildings at Magdalene College are also, I feel, eminently successful if viewed from the picturesque standpoint. Almost the best example of purely negative architecture is, I think, the range at Jesus College, forming the east side of the Chapel Court. Notice what a travesty of the beautiful entrance gateway to this College is the central feature of this building.

We have no modern churches in Cambridge which are of any architectural interest, excepting All Saints, opposite the entrance to Jesus College, built from the designs of Mr. Bodley. The spire to this church is, indeed, beautifully proportioned. The decoration of the interior is by Mr. William Morris, who was also responsible for the decorations to the ceilings of the nave and tower in the Chapel at Jesus College.

The work of Mr. William Morris at Cambridge is of great interest. Perhaps the very best example of his "neo-mediæval" architecture is the decoration and the coloured windows to the Hall at Peterhouse. The screen painting and the roof were erected by Sir Gilbert Scott in 1870. When we consider the Gothic horrors which this period brought forth we cannot but realise how great was the genius of Mr. William Morris. The chief characteristics of his work are striking individuality, intense refinement and a certain note of sadness. His colour schemes lack any touch of gaiety. They are rich and almost sombre in their richness. They go just as far as puritanism dare go without taking one step over the mark. He is, in his conceptions, very much under the spell of one mood, and he has refused to let himself think or act outside it. You say to yourself, as you review his work, "something held this man back." Was it that his horror of vulgarity made him too afraid of committing it?

The work of Mr. William Morris and his coterie has become the work of the past more definitely than the mere lapse of time between his life and ours would justify. It is less the basis of a forward movement than a sudden birth and complete development, a beginning and end in itself. The immortal spark which kindles the enthusiasm resulting in further effort and fresher expression, ever new and ever old, is not there. The work is not that of an architect proper, but rather of a cabinet maker, a worker in precious stones and a painter-decorator. We are indeed thankful for this work, the refinement, delicacy and interest of which is obvious; but there is just a feeling that it would be safer if kept under glass.

The appalling increase in the cost of building since the war has led to a type of building in Cambridge which is very much on American lines. I refer to the latest buildings erected for the purpose of the study of science. During my visit to America in 1918 I made a serious study of the architecture of that country with the view of adopting a similar treatment in England, should the opportunity of doing so occur. On my return to England I realised that the absence of brilliant sunshine would make it extremely doubtful whether or not such an experiment would be successful. In America the least projection casts a deep shadow, and this surface architecture is saved thereby from the poverty stricken appearance which would almost inevitably be a consequence of its use in this country.

The new buildings on Coe Fen for the School of Engineering are purely American in character. They present a baldness which only American sunshine could relieve. In our climate they are naked almost to the point of indecency. I have little doubt that American practical architecture forms a basis upon which to erect cheaper and perhaps more practical buildings in this country, but success in that direction can only be obtained by careful adjustment to suit the character of the English climate. We must so design our buildings that we obtain shadow effects on all but our most hopelessly dull days. Such deeply shadowed trees as the oak and the elm and the beech teach us this lesson, trees which are not common in America, where the lighter maple abounds.

The chimney to the buildings I have just mentioned is extremely graceful and groups admirably with the landscape when viewed from the Coe Fen side of the Peterhouse old wall. Some people may consider it out of place in Cambridge, but few, I should imagine, would deny its grace.

A very satisfactory science building is that erected for Parasitology, by Mr. Redfern, for here we have a quite successful attempt to adjust an American treatment to our own climate. This building is simple and altogether pleasing and, so to speak, "at home," even in Cambridge.

A building does not necessarily fail from the æsthetic standpoint merely because it does not suggest the particular use for which it was erected. On the other hand, it is very much the upholding of its purpose in use which gives the architect his best chance of presenting new æsthetic expression. The building by Professor Prior in Downing Street is undoubtedly a Science building, whereas those in the Court of the main block might almost as well be a new woman's college. As I have stated, I admire Professor Jackson's front to the Geological building, but this architecture is not really expressive of its use, despite the carved representations of prehistoric animals which adorn its base.

There is one more Science building which should be mentioned as deserving our grateful praise. I refer to the National Institute of Agricultural Botany. I hear that the architect claims proudly that it does not represent "Architecture"; but, to my mind, it has just that truly architectural proportion between mass and space which is the basis of all that makes for the "grand manner."

Of the two Women's Colleges in Cambridge, Newnham is rather over-expressive of its use. It has somewhat the appearance of a ladies' drawing-room turned inside out. Perhaps this effect is due to the over use of white paint, although taken as a whole, it does suggest that the architect could not take the idea of University Education for women quite seriously. The architecture (if I may use the word in this connection) of Girton College is so bad and depressing that we may pass it over with the remark that it is overdressed to the point of vulgarity.

If in this paper I have been severe in my condemnation of much of the Modern Architecture of Cambridge, I have, I trust, left the impression with you that we have also a great deal to be thankful for. It is rarely that our architectural failures are devoid of any interest whatsoever, where architects have attempted more than a merely negative collegiate architecture. I feel that many architects who have been privileged to leave their impress upon Cambridge have been just a little afraid of themselves. They have not all given quite of their best. The knowledge that you have a real chance of marking yourself for good or bad is always unnerving. Architectural mistakes cannot be buried away in either Oxford or Cambridge; and he would be indeed a bold man who, while adding to University Architecture, did not at times feel his confidence in himself shaken. Moreover, College authorities do not make easy clients. It is a difficult matter to satisfy all the members of a governing body, consisting of 30 or 40, or even 12, fellows, without lowering your æsthetic standard to some degree. So that it would be unfair to judge all modern Cambridge Architecture upon the assumption that a free hand had been given to the architect. As a matter of fact, a free hand is rarely willingly given to an architect in Cambridge, and it is for him either to get what he wants by the exercise of patience and reasonableness, or if these fail to secure him freedom, to withdraw altogether. There are in Cambridge two parties (reviewing architecture from two diametrically opposed standpoints) composed on the one side of those who believe in advance and the "grand manner," and, on the other, of those who hold fast to past methods of expression and prefer the

picturesque. The true antiquarians are often on the side of the former party, while the general compromisers swell the ranks of the latter.

There is perhaps no body of men in the world which fears derision more than the governing body of a University College. They will always, if possible, anchor themselves upon the rock of past ages which it is irreverent to ridicule. Thus the standard most acceptable to them is just the type of architecture which fails to incite that praise from some which almost certainly means the condemnation of others. They are satisfied if by general consent the addition to their College "does not hurt the older buildings." However, it is impossible to live in Cambridge without becoming aware that a new generation is gaining authority, a generation which believes in its own age and will have none of this deadening compromise. And I feel that there is coming shortly an opportunity for architects of adding to the beauty and interest of Cambridge Architecture to a degree even more startling than that which the architects of the Eighteenth Century used to such advantage.

DISCUSSION.

THE CHAIRMAN (Mr Basil Oliver, F R I B A), in opening the discussion, said the paper had been an extraordinarily interesting one He thought it was a very happy idea to show slides of American work, so that it might be contrasted with English work. In the slides that the author had shown of Cambridge architecture, he thought at first that the best and the worst were put next to one another purposely, but it was really only a coincidence. In his opinion Girton was about the worst, and the slide of of the new Agricultural College, which came next, was most delightful and formed a charming contrast. At the beginning of his paper the author referred to Gibbs' "deliberate break with tradition" when he produced such buildings as the University Library and the Senate House. The eighteenth century architects very rightly worked in the style of their time instead of in a past dead one. In other words, their work, like that of their predecessors, was a living architecture, less picturesque but more refined and scholarly and yet still collegiate in feeling. With the coming of the first antiquarian enthusiasts in the nineteenth century Cambridge, like the rest of the country, suffered from the blight of Victorianism. It might be called fancy dress architecture, because it was not quite serious or sincere; it was in fact, almost as shallow as the art of the scene painter and was totally lacking in the real spirit of Gothic Such ill-digested harking back had always been a harmful curb to free development, though he would be the last to deny the value and even necessity of tradition for the inspiration of modern work Wilkins' Gothic Court at Corpus, though hardly comparable with the Houses of Parliament, had one characteristic in common with the latter, namely, Gothic features on a classic body The author had likened that kind of architecture to a family quarrel, and he thought the simile was a good one. It was difficult to condone Wilkins' lack of interest in his interiors To place windows down at the floor level for the sake of external effect was inexcusable and might almost be termed architectural snobbery It was surely a sign of incompetence to design inwards from a preconceived elevation Planning for convenience and comfort should of course come first as an essential. When the elevations came right, in unison with the plan, then the problem might be said to be successfully solved. Wilkins seemed to have made it his rule to be classical indoors and Gothic outdoors, in one and the same building Such inconsistency and hesitation were deplorable It was no wonder that the result was dull and lifeless, but for that the prevailing romanticism had to be thanked The note at the bottom of several drawings made by Wilkins for the work at Corpus, quoted by the author, made him wonder if the architect was lazy or merely lacked self-confidence Perhaps he had to copy at the bidding of his antiquarian employers, and it was more charitable to make allowances for that. Mere copyism was not art and never could be; the country suffered from it still and it accounted for a great deal of uninspired and bad work. The author touched on that elusive quality known as the "grand manner." To produce truthful building small rooms should have small windows, and it was hard—though he did not say impossible—to reconcile a multitude of small windows, as necessitated by undergraduates' rooms, with dignity and the "grand manner." As the author had said, in many instances at Cambridge palatial buildings had very small accommodation, and that showed that the "grand manner" if misunderstood could have very inconvenient consequences. Wren had a much easier task in the Library of Trinity College, which the author mentioned as the best example of the "grand manner" in Cambridge. It was a somewhat intangible quality, but it was as necessary to good architecture, whether great or small, as balance and right proportion. In forming an opinion on modern work, the difficulties of the custodians of old University buildings in making unavoidable additions from time to time should be taken into account. Colleges must sometimes expand or be otherwise altered to meet modern growth and requirements, and to do that successfully, without spoiling the work which existed,

was the supreme test of an architect's ability. The Fitzwilliam Museum was a case in point. That was described to him by a friend only two days ago as the only complete architectural thought in Cambridge, and he did not envy the task of the architect called upon to add to it. As his friend said, "You can't add anything on to the side of a watch." The author had said in his paper, that the governing body of a University College was usually satisfied if by general consent the addition "does not hurt the older buildings," and that was a very laudable idea as far as it went. The governing body should make sure they got the right architect, and then trust him. He agreed with the author in his intense admiration for the work of George Gilbert Scott, or "Scott the Younger," as he was often called; he was indeed a great architect, whose work should be studied by all students of architecture. It was to be hoped that his very distinguished son, Giles Gilbert Scott, the designer of Liverpool Cathedral, would one day have an opportunity of adding to the interest of Cambridge by producing there an example of the work of the third generation of hereditary genius. The reference made in the paper to the work of William Morris intensified his regret that there was no building in Cambridge designed by Morris' friend, Philip Webb. Had the two collaborated, Cambridge would have become even more of a Mecca for the architectural pilgrim. He greatly liked the note of optimism on which the author concluded his paper. Having seen the author's own very beautiful work in the Chapel of Sidney Sussex College—which he was too modest to refer to in the paper, except to praise his carver—he for one could testify that the author had practised what he had preached, and had added to the beauty and interest of Cambridge architecture He believed Mr. Lyon had some slides of that work and was sure that every one present would be very glad to see them.

(Mr. LYON exhibited and explained the slides).

MR. A. R. POWYS, A R.I.B.A., said he was sure everyone present had very much appreciated the privilege of listening to the author's paper on the architecture of Cambridge. It was exceedingly difficult to give an adequate description of modern buildings and to point out fairly what was good and what was bad in them. There were many points in such a consideration that made a man who was an architect himself hesitate before he gave a definite opinion. The author had given a description of the qualities of the architecture at Cambridge, with a kind of sidelight on the possibilities of future development, in a very fair spirit. Personally he found it a little difficult to grasp at once what he thought was a new meaning the author had given to the old expression, "the grand manner." He did not know whether he had been wrong or not, but he had always associated the "grand manner" with the works of the great eighteenth century men, such as Vanbrugh, Campbell and Kent. The author also referred to picturesque architecture. He thought the words "grand manner" and the word "picturesque" had perhaps gained for themselves recently a meaning which they did not have originally, particularly "picturesque," which now carried with it a kind of sneer. The author showed a slide of the "Malting House," a very beautiful little building which Messrs. Smith and Brewer had repaired and altered, and described it as being in the "grand manner." Personally he would have said that it was picturesque, using the word "picturesque" in its true and original meaning. That of course was a minor point, and if by the expression "the grand manner" was meant fine architecture, it was easy to accept it. With regard to the author's reference to the work done by William Morris as an isolated feature in the progress of art, personally he did not consider that was so It was true that William Morris himself was so versatile and had such a mastery of so many arts that there was no one who could follow him in that way, and in that sense he considered that his school and the feeling he put into his work were dead, but he felt that William Morris and his friend Philip Webb had done more for modern architecture and for the architecture that was to come than perhaps any two men of the last century. He held that opinion very strongly, and he fancied that possibly the excellent work done by the author, which had been shown on the last slides exhibited, was largely due to the work of William Morris and Philip Webb, although the author might be quite unconscious of it. He knew that the Chapel of Sidney Sussex College was in a manner which neither Morris nor Webb would have used, but at the same time there was about it a spring of inspiration, a desire to advance rather than to copy and imitate, which was perhaps at the base of their work.

MR. HALSEY RICARDO, F.R.I.B A., said he had been exceedingly interested in the paper and in the slides that had been shown. He was very much impressed by the author's remark about the almost promiscuous way in which Cambridge had been allowed to develop of late years, and how buildings had been dotted about in the College grounds without any preconceived plan. Personally he thought that was a very serious but a very just criticism of the College authorities. With reference to the author's suggestion that the tower of Caius' College should be removed, he would deprecate any such action. The construction was sound and very fine in a way; the building was well planned and carried out with the sincerity that Waterhouse always exhibited. It might not be a sincerity that was acceptable at the present time,

but the building was sincere, workmanlike and craftsmanlike, and, apart from the absence of aesthetic feeling, it was a fine building and was entitled to a respectful preservation. It must be remembered that there was such a thing as fashion in architecture, and that fashions changed. He could remember very well the time when it was considered a mark of culture amongst undergraduates in Oxford to wave Keble College away with scorn ; if anyone had a word to say for it he was without the pale With regard to the expression "picturesque architecture," to which the author and Mr Powys had referred, he took "picturesque architecture" to mean fundamentally such architecture as a painter would like to represent in a picture. A painter in the real sense of the word, an artist, was of course a poet, and what concerned him was not so much perhaps the actual appearance, although that received consideration, as the sense and atmosphere of humanity. It was wrong and absurd for an architect to attempt to build picturesquely A building became picturesque because successive generations of men had lived in it and hoped and feared and suffered in it, and had also developed it as the need arose A very simple test was to think of one's feelings when contemplating a ruined abbey or other ancient building It had a pathetic interest. The ruin in itself might not be beautiful at all, it might be shapeless and ugly, but it was so charged with human history that it appealed to nearly everybody. He thought no new building could be called picturesque, because it lacked that human quality It had, however, some human qualities : it had the architect's and the craftsman's care and interest in the matter, but that was scarcely sufficient. Time was required to develop the picturesque, and that was why certain buildings such as museums and galleries could hardly be called picturesque. On the other hand, many such buildings had an element of romance in them, such as the Senate House and Library of King's He might mention that Wilkins built the National Gallery and also University College in Gower Street, and he did not know any more romantic and dramatic or picturesque buildings of their kind than those two, except perhaps the British Museum, which was another example of magnificent, grand, picturesque and romantic building. He would not speak disrespectfully of College Dons any more than he would speak disrespectfully of the equator, and he quite understood their difficulties, but he thought it should be vociferously declared that architecture was a living structural art, and that, although it was based on tradition of craftmanship, style and so forth, and had a varying vocabulary in different ages, real architecture was a living affair. Therefore the feeling that in making an addition to a College or any other building one must be careful not to hurt the building was not so true as it sounded, although it was true in a sense. Taking an example such as the Inigo Jones front to Worcester College, which was strictly classic, formal and severe in a way, with the most charming congeries of old buildings alongside, the combination was most delightful. There could be a great deal too much insistence upon an addition being made so as not to hurt the old building, and it led to a tendency to recall the past, when the past was out of tune with the present day People now had different views and different ideals, and had also different methods of construction and different materials to some extent Therefore, it was greatly to be regretted that College Dons twisted their heads round so that they looked backwards over their shoulders ; they should remember that when Orpheus did that he lost Eurydice.

MR S. C. COCKERELL, referring to the remarks made by the author and Mr. Powys about the work of William Morris in Cambridge, said the work ascribed to Morris was not his work only but the co-operative work of Morris, Philip Webb, who did a considerable amount of work in Cambridge in the way of window designing, Burne-Jones, Madox Brown and Rossetti They did work together in Queens' College and Peterhouse, and Burne-Jones, Madox Brown and Rossetti worked in Jesus College A great deal of the decoration in All Saints' Church might be called Morris', but it was really an example of the very early work of the firm. It was co-operative work. Morris was no more concerned in it than others— perhaps less so— except that he conducted the business side of the firm There was not very much decoration in the church, but the main east window was very interesting, because it had some cartoons by Morris, some by Burne-Jones and some by Madox Brown, and it was known to very few people which were which. He happened to have a copy of a chart which showed that

MR. JOHN SLATER, F.R.I B.A , in proposing a vote of thanks to Mr. Lyon for his extremely interesting paper and particularly for the beautiful slides he had shown of the Cambridge buildings, said the author suggested that the modern architects who had designed buildings in Cambridge had perhaps hardly done justice to themselves. Might not it be that they were so overwhelmed by the traditions of the place that they really had not been themselves in the work they had done ? Mr. Ricardo had mentioned the well known fact that fashions changed in architecture from generation to generation. One of the most striking instances of that occurred in the preface to a book written by Quatremere de Quincy on the lives of the most celebrated architects, where he said : "There be found in this volume not a single word about that style of architecture which is called Gothic, for we maintain that no architecture is worthy of the name that does not depend upon the

principles and the motives of Greece and Rome." That was written by a man who had within his view all the glorious Gothic cathedrals of France, and yet he could see no beauty in them at all. He thought everyone would agree with the author as to the undesirability of erecting buildings in Cambridge without any definite plan, dotting them about here and there, for there could be no doubt that much of the beauty of the old buildings in Cambridge and in Oxford lay in the magnificent quadrangles round which they grew.

The resolution of thanks was carried unanimously.

MR. T H. LYON, in reply, said that with reference to Mr Ricardo's remarks he did not suggest that the whole of Caius College should be pulled down; he was only referring to the tower of the building.

The meeting then terminated.

CORRESPONDENCE.

INDUSTRIAL FATIGUE RESEARCH.

As Chairman of an Advisory Committee which has concerned itself with the "Care and Settlement of Subnormal Workers (ex-Service men) in Rural Industries," I should like to make a short statement on this subject, which must be intimately connected with the work of the Industrial Fatigue Research Board. The scheme of our Committee was to establish what has long been known on the Continent as middle and minor industry, in the rural districts of England, by means of small workshops, under a co-operative system. We have had in mind the large class of subnormal, or substandard, workers, injured in war, who are not always able to work six days a week and eight hours a day, and who—we have reason to think—will find a permanent settlement and occupation in lesser industries of this character.

Most important experience has now been gained in the Training Centres during the last few years, especially as regards partially disabled men. I understand that these men are no longer now received for training in ordinary trades, but that a new policy is to be adopted. Suitable minor and middle industries, both congenial and lucrative, and hitherto mainly carried on abroad, are now likely to be established in country districts throughout England for these men.

This being so, it seems important to consider what are the conditions under which such men can be trained and settled in such occupations with any prospect of success. As a result of considerable personal experience, I should like to offer four propositions:—

(1) *Regulation of Work*. That it is necessary for the success of reduced workers in rural industry, that the amount and nature of work done by each man shall be definitely prescribed, with due regard to his physical and mental condition from time to time.

(2) *Measurements, Records and Research.* That an approved and uniform procedure be adopted for measuring and recording each man's condition. In the case of subnormal and injured men the periodical observations should include:—
   (*a*) Condition of limbs (Arthrometry).
   (*b*) Condition of muscular power (Dynamometry).
   (*c*) Breathing Capacity (Spirometry).
   (*d*) Mental power and reactions (Psychometry).

A register of the capacity and fitness of all workers should be kept, and records made every three months

(3) *Visiting Medical Staff* As small industries will be widely scattered, and the workers will not be concentrated in large aggregations, it seems advisable that the necessary examinations and records should be undertaken by a small skilled visiting staff.

(4) *Treatment.* The remarkable success which has attended the large number of clinics established by the Government for out-patient treatment suggests the advisability of adopting the same principle for subnormal workers in minor industries and on the land, throughout the country It has been clearly demonstrated that medical oversight of this kind greatly promotes the fitness of the workers, and increases their economic value.

R FORTESCUE FOX, M.D.

AFRICAN OIL PALM IN MALAYA.

According to a report by the United States Vice-Consul at Singapore, the Government of Perak, one of the Federated Malay States, is prepared to grant land, upon very favourable terms, for the cultivation of the African oil palm. At present the chief countries of origin of this palm and oil are Southern Nigeria, the Gold Coast, Sierra Leone, the French Ivory Coast, and Kongo.

The Department of Agriculture of the local Government and the managers of several rubber plantations have been conducting experiments, and have found that the soil and climate of Malaya are so well adapted to this tree that its oil content is equal to those grown in South Africa. It is thought that as Malaya has the advantages of available labour and facilities for transportation, the cultivation of this palm could be carried on most successfully.

The oil is used mainly in the manufacture of butter substitutes and soap, and has proved valuable for such purposes. It is presumed

that its use would be similar to that of the coconut, the meat of which was in 1909 ground and mixed and placed upon the market as "Palmira" by a German firm in Mannheim. This was a hard, snow-white vegetable cooking fat, and when mixed with the yolk of an egg and water made a very good substitute for butter.

The Government is clearing 50,000 acres of land for oil-palm plantations, which in itself means an increased demand for tractors, stump pullers, portable saw machinery, ploughs, vegetable-oil mill machinery, and kindred equipment.

Perak is on the west coast of the Malay Peninsula and has an estimated area of 7,875 square miles. The State is well watered by numerous streams and rivers. The Perak River, the most important stream, is navigable for about 40 miles from its mouth by small steamers of 300 to 400 tons burden, and thence navigable for another 100 miles by cargo boats. There is no true rainy season, but the wettest months are October, November, and December. In the Krian district the Government has completed an extensive and costly irrigation scheme, and large areas are under rice, sugar, and rubber. The Chinese and the Tamil natives of India form the great bulk of the labour force of the State.

In addition to over 880 miles of metalled roads and a great number of other roads, the Federated Malay States Railway runs from Parit Buntar to Tanjong Malim, the entire length of Perak, and is connected with the coasts and interior by means of branch lines.

BRISTLE INDUSTRY IN POLAND.

Before the war statistics recorded a total of 5,812,000 hogs in the territory now comprising the Republic of Poland. The number of hogs since the war has diminished considerably, but is now on the increase, and Polish dealers expect a normal production of 5,812,000 pounds of bristles per year to be possible in the near future. On the average a hog gives 1 pound of bristles.

The better grades of Polish bristles were exported. For local consumption the Polish manufacturers were accustomed to use the Russian bristle, which is stiffer. The Polish bristle is of the best technical quality, being long and elastic.

Leipzig was formerly the heaviest buyer of Polish and Russian bristles. The tendency at present, writes the U.S. Trade Commissioner at Warsaw, is for Warsaw not only to clean and assort the bristles as before the war, but to replace Leipzig in importance for the direct exportation to the United States, France, and the United Kingdom. Recently a corporation known as Ostoje was organized in Warsaw to engage in this business.

KAURI GUM INDUSTRY IN NEW ZEALAND.

The kauri-gum industry, which has been an important factor in and around Auckland for half a century, is taking on new impetus since the closing of the war. In the past most of the work was done by hand and by individuals. Something like gold was mined years ago in new fields, with the result that the top had only been skimmed over and the better pockets dug out. These methods have secured about £20,000,000 of kauri gum to date, and it is claimed that there is still left in the kauri fields gum and by-products worth at least two or three times what has been taken out.

Until recently the development of the kauri gum fields has been left entirely to private enterprise, but about three years ago the New Zealand Government established a department for the supervision and encouragement of the industry, with the result that more extensive operations are being undertaken by companies as well as by individuals. It is now proposed, writes the U.S. Consul-General at Auckland, to develop the industry along more systematic and scientific lines than those hitherto employed.

From twelve to fifteen thousand tons of kauri gum will, it is expected, be produced per annum, instead of eight or nine thousand tons, as was the case previous to the war, to say nothing of the by-products, which are estimated to be worth as much as, or more than, the gum itself. One company anticipates an output of eight to nine thousand tons of gum per annum and there are besides many private individuals at work in different sections of the field, and other interests are contemplating putting in new up-to-date plants.

The latest undertaking is to gather the gum mechanically from the peat, or pukau, which is really the damaged kauri gum in the low or swampy land found in the territory around Auckland. This is to be worked by what is known as the sluice process, similar to sluicing for gold. The peat is placed on a screen and water forced through it. The screen gathers the chip gum and allows the waste or tailings to drop beneath. This chipped gum is divided into about 15 per cent. first quality, 15 per cent. second quality, and 70 per cent. low grade. The tailings are converted into kauri-gum oil in a manner similar to extracting oil from shale. It is estimated that 40 to 50 gallons of kauri-gum oil can be taken from a cubic yard of pukau. This oil is a very valuable commercial oil, containing a large percentage of motor spirit and turpentine.

It is stated that one company in Auckland has control of kauri-gum rights covering 47,000 acres, estimated to contain 13,000,000 cubic yards of pukau. In addition, the New Zealand Government still holds kauri-gum reservations that are estimated to contain an even larger quantity of pukau, to say nothing of many private interests holding small sections of kauri

swamps. This will give some idea of the real size of the industry that means so much to the paint and varnish industries, as well as to the linoleum and rubber manufacturers.

The New Zealand Government is allowing persons to stake out tracts or claims of three acres on the Government reservations, for which the individual operators must pay 10 per cent. of the value of the gum taken from these swamps It is said that a large number of claims are being staked out.

In addition to the gum and oil that can be extracted from the pukau, there are large numbers of buried kauri trees, from which great quantities of oil can very easily be extracted by a process similar to that used in extracting turpentine from pine logs

GENERAL NOTE

INDIAN LABOUR FOR BRITISH GUIANA — The visit paid to India some two years ago by representatives of British Guiana in connection with the Indian Immigration question seems to be having good results. The Government at Georgetown having promised to introduce a legislative measure conferring equal political rights on Indian Colonists, the Government of India is despatching a deputation to British Guiana to investigate the local conditions and to ascertain whether further guarantees affecting the status of Indians are necessary The deputation consists of Mr. G F Keatinge, I C.S, and two native Indian gentlemen, one of whom is Deputy President of the Madras Legislative Council and the other is prominently identified with the "Servants of India" The singular emptiness of British Guiana, a fertile land as large as Great Britain, with a cultivated area only one-fifth the size of Kent, was well brought out by Sir Walter Egerton in the paper on "British Guiana and the Problem of its Development," read by him before the Dominions and Colonies Section of the Society in 1918 He compared the population with that of some of our other tropical colonies. The population of the British West Indies in one-eighth the area was, three years ago, 1,800,000— six times that of British Guiana; in Ceylon, 4,500,000 British Guiana, three and a half times as large, has only one-fifteenth of Ceylon's total. The Straits Settlements and Federated Malay States boasted a population of 2,000,000.

*MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, DECEMBER 5 .. Farmers' Club, at the Surveyors' Institute, 12, Great George Street, S.W., 6 p.m. Annual General Meeting. Dr. M. J. Rowlands, "Scientific Pig Keeping, and its Relation to Vitamines."

Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mr. G. M. Gathorne-Hardy, "A Recent Journey in Northern Labrador."

Chemical Industry, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. W. L. Baillie, "An autoclave Test for the Grading of Chemical Glassware." 2. Dr. E. Fyleman, "Separation of Adherent Oil or Bitumen from Rock."

TUESDAY, DECEMBER 6 .. Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. H. M. Edmonds, "A New Mode of Producing Sculptures by the Aid of Photography."

Metals, Institute of (Birmingham Local Section), at the Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Mr. G. W. Mullins, "The Early History of Copper and Bronze."

WEDNESDAY, DECEMBER 7 .. Geological Society, Burlington House, W., 5.30 p.m.

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. J. Baker, "Some Problems of Unemployment."

Book-keepers, Institute of, at the Haberdashers' Hall, Gresham Street, E.C., 6.30 p.m. Mr. R N. Carter, "An Introduction to the Study of Income Tax."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section). Mr. T. L. Eckersley, "An Investigation of Transmitting Aerial Resistances."

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. B. S. Evans, "The Estimation of Small Quantities of Antimony in Copper and Brass." 2. Mr. A Lucas, "The Inks of Ancient and Modern Egypt" 3. "Mr. C. L. Claremont, "Notes on the analysis and use of Red Squill in Rat Poisons."

United Service Institution, Whitehall, S.W., 2.30 p.m. Lt.-Col. W D. Croft, "The Influence of Tanks upon Tactics."

University of London, South Kensington, S.W., 5 p.m. Sir Frederick Bridge, "Sir W Leighton's Great Collection of Early 17th Century Motets by Eminent English Composers." (Lecture II)

African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m.

THURSDAY, DECEMBER 8 . Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C, 7 p.m.

University of London, at the Imperial College of Science, South Kensington, S W., 5.30 p m. Mr. W. Bateson, "Recent Advances in Genetics." (Lecture VI.)

Garden Cities and Town Planning Association, King's College, Strand, W C 5.30 p m. Lecture on "The City of Milan."

Camera Club, 17, John Street, Adelphi, W.C., 8 15 p m Captain H. Lambart, "The Intricacies of the Silent Drama and its Making."

Historical Society, 22, Russell Square, W.C., 5 p m Mr H G Richards, "Year Books and Plea Rolls as Sources of Historical Information"

Antiquaries, Society of, Burlington House, W., 8.30 p m.

Optical Society, at the Imperial College of Science, South Kensington, S.W., 7 30 p.m.

Mechanical Engineers, Institution of (Midland Branch), The University, Edmund Street, Birmingham, 7 30 p m Mr. C. V A. Eley, "The Turbine Furnace."

Metals, Institute of, Cannon Street Hotel, E.C., 8 p.m. (Joint Meeting with Institution of British Foundrymen) Mr. S. A. E. Wells, "Casting in Metal Moulds."

FRIDAY, DECEMBER 9 . London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C., 4 30 p.m. Mr. C. H. Grinling, "The Heights Around London."

Japan Society, 20, Hanover Square, W, 5 p.m. Mr. W. L. Schwartz, "The Potters and Pottery of Satsuma."

Astronomical Society, Burlington House, W., 5 p.m.

Electrical Engineers, Institution of (Irish Centre), Royal College of Science, Dublin, 8 p.m. Mr. F. E. Walker, "Electrical Vehicles; their Design, Construction and Potentialities."

Malacological Society, at the Linnean Society, Burlington House, W

Physical Society, at the Imperial College of Science, South Kensington, W., 5 p.m.

Engineers, Junior Institution of, at the Royal United Service Institution, Whitehall, S.W., 7.30 p.m. Presidential Address by Mr. C. H. Wordingham.

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meeting of the ROYAL SOCIETY OF ARTS, see page 48

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 12th, at 8 p.m. (Cantor Lecture.) ARTHUR M. HIND, O.B.E., M.A., Assistant-Keeper, Department of Prints and Drawings, British Museum, and Slade Professor of Fine Art in the University of Oxford, "Processes of Engraving and Etching." (Lecture III.)

WEDNESDAY, DECEMBER 14th, at 8 p.m. (Ordinary Meeting.) SIR WALTER BEAUPRÉ TOWNLEY, K.C.M.G., Minister to the Netherlands, 1917-19, "Trade with the Netherlands East Indies." THE RIGHT HON. LORD EMMOTT, G.C.M.G., G.B.E., in the chair.

Further particulars of the Society's meetings will be found at the end of this number.

FIFTH ORDINARY MEETING

WEDNESDAY, NOVEMBER 30th; SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works and Public Buildings, in the Chair.

The following candidate was proposed for election as a Fellow of the Society:

L. D. Varshnei, Bahjoi, India

The following candidates were balloted for and duly elected Fellows of the Society:

Blagg, Percy, London.
Elton-Bott, John Richard, Burma.
Ross, Alexander G., Fiji.
Sanders, Marion Eugénie, London
Wright, Hugh Francis, New Barnet, Herts.

A paper on "The Preservation of Stone" was read by MR. NOEL HEATON, B.Sc.

The paper and discussion will be published in the *Journal* of December 30th.

CANTOR LECTURES.

On Monday evening, December 5th, MR. ARTHUR M. HIND, O.B.E., M.A., Slade Professor of Fine Art in the University of Oxford, delivered the second lecture of his course on "Processes of Engraving and Etching."

The lectures will be published later on in the *Journal*.

DOMINIONS AND COLONIES SECTIONS.

TUESDAY, DECEMBER 6th; THE DUKE OF DEVONSHIRE, K.G., G.C.M.G., G.C.V.O., in the chair. A paper on "British Columbia—The Awakening of the Pacific" was read by MR. FREDERICK WADE, B.A., K.C., Agent-General for British Columbia.

The paper and discussion will be published in the *Journal* of January 6th.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 4th and 11th January, 1922, at 3 p.m., by Mr. William Reginald Ormandy, D.Sc., F.I.C., on "Clay: What it is—Where it comes from—and What can be done with it." The lectures will be illustrated with experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, NOVEMBER 23RD, 1921.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

THE CHAIRMAN, in opening the meeting, said that the Lecture about to be delivered by Prof. Fleming was a "Trueman Wood" Lecture, i.e., one of the Lectures that had been instituted by the Society in commemoration of the 42 or 43 years that Sir Henry Trueman Wood had passed in the service of the Society. It had been hoped that Sir Henry would have been able to attend the meeting, but unfortunately he was not able to do so. He thought he was right in saying that Professor Fleming had given more Lectures in the Hall of the Royal Society of Arts than any other living person. He had been associated with Senatore Marconi and with the Marconi Company for many years and had written most comprehensive books on the subject of wireless telegraphy, and there was no one more competent to deliver a Lecture on the coming of age of long distance wireless telegraphy.

THE COMING OF AGE OF LONG DISTANCE RADIOTELEGRAPHY AND SOME OF ITS SCIENTIFIC PROBLEMS.

By J. A. FLEMING, M.A., D.Sc., F.R.S.,
Albert Medalist of the Royal Society of Arts.

FIFTH TRUEMAN WOOD LECTURE.

I. HISTORICAL.

1. Almost exactly 21 years ago a small building had been erected in a lonely spot on the coast of Cornwall, called Poldhu, at the extreme West of England, and was being equipped with machinery for an experiment of transcendent interest. (See Fig. 1.)

Senatore Marconi had during four years previously given innumerable demonstrations of the utility of the apparatus he had devised for transmitting intelligence by electromagnetic waves over land and sea, and had telegraphically covered distances up to about 100 miles. These achievements stimulated in him a desire to try for greater things, and to attempt to fling electric wave signals across the Atlantic Ocean. Although

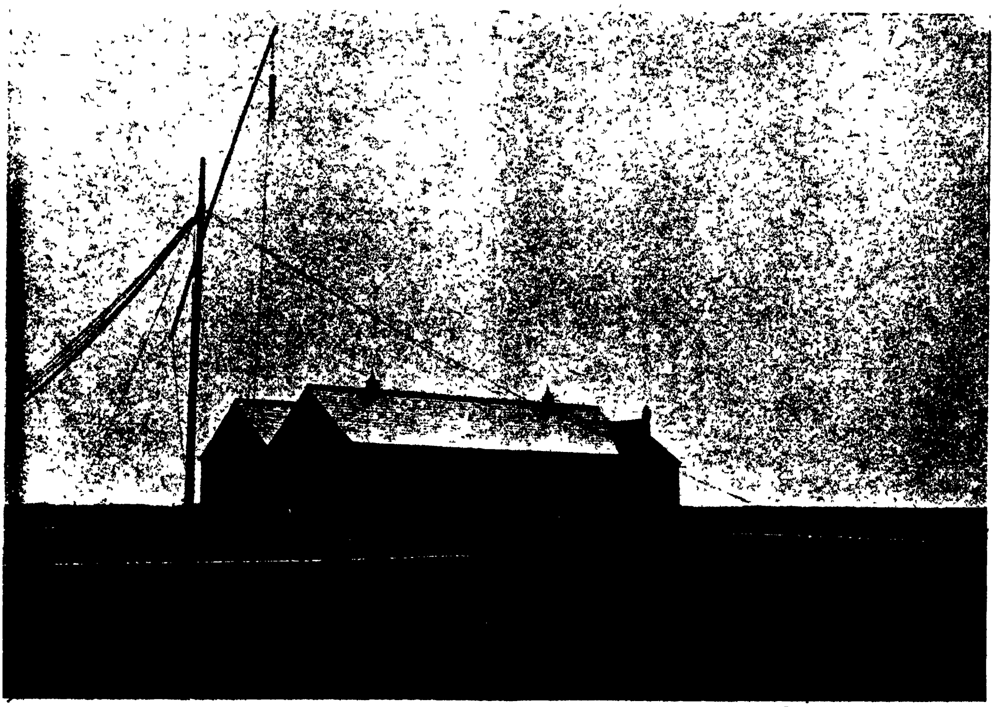


FIG. 1.—First Building erected at Poldhu, Cornwall, England, for long distance wireless telegraphy in the autumn of 1900, by Marconi's Wireless Telegraph Company, Ltd

more cautious pioneers might have hesitated to take the leap from 100 miles to 2,100 miles in one step, yet with characteristic courage he decided to attack the problem of long-distance radiotelegraphy without delay. The curious thing is that all of us, inventors and scientists alike, were then completely in ignorance of the secret arrangements made in Nature for facilitating and also for hindering these ambitious schemes. To some of these we shall presently refer.

The first question was that of power. Up until then only a 10-inch spark coil actuated by a dozen storage cells had been employed for the transmitter, using perhaps 150 watts and radiating may be 5 or 10 watts from the aerial.

The conversion of this laboratory apparatus into engineering plant had to proceed tentatively in the absence of all previous experience, but part of the duty of specifying for it having been laid upon your lecturer, he recommended for this initial attempt a 32-h.p. Hornsby-Ackroyd oil engine driving a 25 k.w. Mather and Platt 50-cycle alternator providing current for two 20 k.w. Berry transformers, stepping up voltage from 2,000 to 20,000. Six months previously Mr. Marconi had applied for a patent, No. 7,777, of April 26th, 1900, for a noteworthy modification of his original system in which electric oscillations produced by the discharge of a battery of Leyden jars through one coil of a transformer were made to induce syntonic oscillations in the aerial connected to its secondary circuit, and at the receiving end the oscillations picked up by the receiving aerial were caused to create others in a tuned closed condenser circuit. This important patent was subsequently upheld in litigation as a fundamental invention, and it carried to their logical issue and gave practical form to the recommendations made in a prior British patent by Sir Oliver Lodge (No. 11,575 of 1897) as to the necessity for syntonic agreement between sending and receiving stations and the advantage of using feebly damped waves.

This system was described by Senatore Marconi to the Royal Society of Arts in a paper read on May 15th, 1901, entitled "Syntonic Wireless Telegraphy." (1) The actual arrangements first made at Poldhu comprised a modification of this syntonic system in which a double transformation with two spark gaps and two sets of condensers were employed as described in British Specifications Nos. 20,576 and 22,126, of 1900, and No. 3,481, of 1901, granted to me.

This large scale work necessitated the design of a durable form of condenser less bulky than Leyden jars, and they were constructed by placing 20 glass plates 16 inches square coated on each side with a square foot of tinfoil in stoneware boxes filled up with linseed oil. Each box had a capacity of $\frac{1}{18}$ of a microfarad.

The signals were made by short circuiting choking coils inserted in the alternator circuit on the low tension side of the transformers. The earliest troubles occurred with the spark balls, owing to the production of an arc discharge by the transformer. Some of these difficulties were minimised by the use of dischargers made with two massive iron discs kept in slow rotation by electric motors and the use of an air blast, but not finally overcome until Senatore Marconi invented his high speed rotating studded disc dischargers in which the arc discharge was blown out by the blast of air due to rotation, but the condenser oscillating discharge remained. It should be noted that the discharge so produced is quenched and consists only of two or three oscillations. This, however, is a great advantage, as it prevents the back transfer of energy from the aerial and prolongs the oscillations produced in it. These dischargers also greatly increased the possible speed of signalling.

2. The general arrangements used in the plant with which the first radio signals were

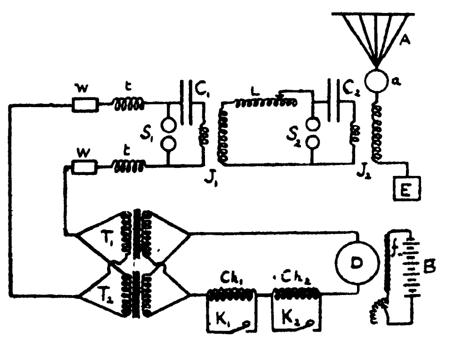


FIG. 2.—Circuits of first spark transmitter used at Poldhu, 1901.

A, aerial; C_1, C_2, Condensers; S_1, S_2, Spark balls; J_1, J_2, Jiggers; T_1, T_2, Step-up Transformers; Ch_1, Ch_2, Chokers; K_1, K_2, Keys; D, Alternator; B, Storage battery; E, Earth.

(1) See *Journal of the Royal Society of Arts*, May 17th, 1901 Vol 49, p. 505.

thrown across the Atlantic in December, 1901, were as follows:—

The alternator D (see Fig. 2) was driven by the oil engine at a speed which gave about 45 cycles per second, and its low frequency voltage of about 450-600 was stepped up by two transformers T_1 T_2 in parallel, choking coils Ch_1 and Ch_2 were inserted, which cut down the primary current unless they were short-circuited by keys. The high tension voltage of the transformers was used to charge a condenser C_1 of 1.43 mfds. capacity, and this was discharged across the 7.5 mm. spark gap S_1. Other coils, W, were inserted to tune the condenser to the low frequency transformer circuit. The oscillatory current was passed through a transformer J_1, having a step-up voltage ratio of 1 : 10, and this in turn charged a condenser C_2 of 1/27th mfd. capacity which discharged across a 40 mm. spark gap S_2. Those last oscillations were inductively transferred to the aerial by an oscillation transformer J_2 with ratio of 1 : 10. The aerial consisted of 54 7/20 copper wires arranged fan-shape and upheld by a triatic stay between two masts 150 feet high. The current into this aerial measured at the base was about 17 amperes. Its capacity was probably not far from 0.003 mfd. The wave length (not measured) was perhaps about 1,000 metres.

3. This plant was completed and tested for short-distance working during 1901, and Mr. Marconi left England on November 27th, 1901, in the *s.s. Sardinian*, taking with him his assistants, Mr. Kemp and Mr. Paget, and also a number of balloons and kites. His intention was to elevate a temporary receiving aerial in Newfoundland and endeavour to detect the signals sent according to a plan from Poldhu. On arriving at St. John's in Newfoundland, he secured the kind co-operation of the Governor, Sir Cavendish Boyle, and the Premier, Sir Robert Bond, and found a suitable station in a Government building on Signal Hill. He sent word for the signalling to begin at Poldhu, sending the letter S (three dots) at certain hours. After some difficulties in elevating his kites and wires, he was able on Thursday, December 12th, 1901, to state that he had certainly received signals from Poldhu, detected by a suitable coherer and telephone in Newfoundland, and on December 14th, 1901, he cabled this information to England. The actual power used in driving the alternator was not above 10 or 12 h.p., but, of course, a mere fraction of this was radiated in the form of electric waves.

These profoundly interesting experiments were, however, brought to an end by the Anglo-American Telegraph Company, who had a monopoly of receiving in Newfoundland transatlantic messages until April, 1904, and they entered a demand for this research work to cease. Nevertheless, enough had been done to show that transatlantic radiotelegraphy was not an impossibility, but fully practicable with suitable arrangements.

It was, at any rate, enough to obtain for Senatore Marconi the necessary support to erect permanent masts and aerials and transmitters both at Glace Bay, Nova Scotia, and at Cape Cod, Mass., U.S.A., and a year later, on December 21st, 1902, he was able to dispatch wireless messages across the Atlantic which made long-distance radiotelegraphy a demonstrated achievement.

4. Much, however, remained to be accomplished before transatlantic radiotelegraphy could reach a commercial stage. For one thing, experience had shown the necessity for much larger power in the aerial, and it was considered advisable to establish first two new permanent stations: one at Clifden, in Connemara, Ireland, and the other at Glace Bay, Nova Scotia. These stations were sufficiently advanced by the middle of 1907 to admit of telegraphic work being undertaken, and a limited service of press messages was inaugurated. But a disastrous fire at the Glace Bay Station in August, 1909, caused delay, and it was not until April, 1910, that regular communication between these stations for public use was re-established. Meanwhile, however, even in 1907 it had been demonstrated that the demands for accuracy and speed could be fulfilled by a wireless transatlantic service.

II. Spark Systems.

5. It is impossible to follow out in detail here all the changes which were made in the working plant of these pioneer long-distance stations between 1902 and 1910. Suffice it to say that an early improvement in the arrangements at Poldhu consisted in increasing the group frequency of the spark discharges, which was necessitated by the introduction of the telephonic method of reception and the invention of his beautiful magnetic detector by Marconi in 1902.

The low frequency alternator was replaced by one having a frequency of 200 or more so as to raise the pitch of the note heard in the telephone, which is that of the spark frequency, and make it more easily distinguishable above the sounds due to atmospheric disturbances. Also the oil engine was replaced by a steam engine to give more uniform turning movement. This improvement was carried still further in the first arrangements at Clifden. The alternator and transformers were abolished and a battery of 6,000 small storage cells was kept charged by a number of high voltage direct current dynamos run in series. These cells kept a large air condenser charged and this was discharged through the primary coil of an oscillation transformer, the secondary circuit being in connection with the aerial and the earth. This condenser had a capacity of two mfds. and was formed of large iron plates hung 12 inches apart. It had, therefore, negligible energy loss. The discharges were made at the rate of 500 or 600 per second by a studded disc rotating discharger. Any arc formed was extinguished at once, but the feebly damped oscillations survived and produced in the telephone at the receiving end a high musical note more easily read above the sounds of the atmospherics. Investigations had shown by that time the advantages of increased wave length for long-distance working, and it was raised to 5,000 or 7,000 metres in the early work at Clifden and Glace Bay. It is probably not necessary to refer here at length to other types of intermittent spark generators of electric waves such as the Quenched Spark devised later on, since, although these have still a field of utility for short or moderate distance working, the continuous wave system has proved to have such incontestable advantages for long distances that no one would at the present date propose to equip a long range high power station on the intermittent spark discharge system.

6. The Timed Spark generator forms, however, the connecting link between the true spark systems and the continuous wave generators. It was developed by Senatore Marconi as an application of his high speed rotating dischargers before any of the other present-day methods of creating powerful continuous oscillations had arrived at maturity. This method of generating powerful undamped oscillations in an aerial wave produced by the free discharges of condensers was adopted in the large Marconi stations at Carnarvon, N. Wales, England, and New Jersey, U.S.A., and Stavanger, in Norway, which were completed just before the great war in 1914 and intended for public transatlantic telegraph service. In this system two large batteries of condensers are kept charged by direct current dynamos producing current at 5,000 to 10,000 volts or so. These condensers are discharged alternately through the primary coils of transformers, the secondaries of which are in series with the aerial and earth. The discharge is effected by two studded disc dischargers driven by a motor and keyed to the same shaft, but with fixed electrodes so placed that the condensers are discharged in such fashion that the discharge of one condenser begins just before the oscillations produced by the other condenser finish. In order to produce exact continuity and join up the groups of oscillations in the aerial in step, the discharges are regulated by a timing or trigger disc. The studs on the revolving discharges are set just so far away from the fixed contacts that the main condensers cannot discharge across until the air in the gap is ionised by a small pilot spark. This is provided by the timing discharger just at the right intervals, and the result is to create in the aerial a practically undamped oscillation with slight fluctuations of amplitude at regular intervals. The signalling is conducted by interrupting the charging current (about 0.5 ampere) of the small condenser in the timing disc circuit so that the manipulation of a very small amount of power, perhaps a few watts, controls a radiation of a hundred kilowatts or more from the aerial.

7. In connection with these pre-war long-distance stations of the Marconi Company, two inventions of Senatore Marconi are noteworthy, viz., the inverted L directive aerial and a simple yet very practical method of duplex transmission and reception. (2) This last is achieved by the plan of separating the receiving station from the transmitting by some miles. In the case of Carnarvon, the receiving station is at Towyn on the coast of Wales, 60 miles away. At the latter there are two aerials, one large for distant reception, and one small balancing aerial placed in a particular position, the function of which is to neutralize on the receiving circuits the effects of the powerful

(2) See British Patent Specification. G. Marconi; No. 14788 of 1905.

waves from the near-by transmitter, whilst not much neutralizing the feebler waves coming from the distant transmitter.

The sending aerials in these large spark stations are enormous structures supported on ten steel masts 400 feet high upholding an antenna of multiple horizontal wires about 3,000 feet long and 400 feet above the ground. The earth plate system is also co-extensive with it. The radiated wave length is about 14,000 metres or nearly 10 miles, but the natural wave length of the aerial alone is 5,600 metres.

The signalling can be done locally in the Carnarvon station or it can be controlled from the Towyn receiving station, and even by means of Creed perforators automatically conducted by the ordinary telegraphic line currents dispatched from London.

It is now generally the custom to separate the receiving station from the home transmitting station by a distance of several miles and to receive on frame aerials placed in the right position as regards the distant transmitting station.

III. The Arc Oscillation Generator.

8. We must then return in point of time to our starting point in 1900 and glance at other collateral inventions in connection with long-distance radiotelegraphy which developed alongside of the spark-discharge system. In that year the late Mr. Duddell described a new method of creating electric oscillations by shunting a direct-current arc, formed between solid carbons, by an inductance and condensers in series.(3) With the ordinary carbon arc in air it was necessary to employ rather a large capacity, viz., 1 to 5 mfds., and an inductance of about 5 millihenrys to obtain oscillations of any vigour in the shunt circuit, and hence their frequency was necessarily low and far too low to be of use in radiotelegraphy.

The phenomenon is essentially dependent upon the fact that for such an arc the characteristic curve of electrode potential difference in terms of arc current is a downward sloping curve.

Even after all the research on this so-called musical arc the exact reasons for this negative slope of the characteristic are not absolutely determined.

The arc discharge consists in the continual ionisation of the carbon vapour with resulting movement of heavy positive ions towards the cathode and negative electrons towards the anode. The ionic bombardment of the electrodes keeps up their temperature and the supply of vapour. There is probably also an accumulation of negative ions round the positive carbon tip and of positive ions round the negative carbon, and these create that steep drop in potential which exists near the electrodes. It is well known that a gaseous conductor does not obey Ohm's law; that is, the conductivity is not constant and independent of the current. The conductivity of an ionised gas depends upon the number of ions present per unit volume and upon the velocity which these can acquire under unit electric force.

If the current through a gas increases, this means that the velocity of the ions increases, and this may result in an increased production of ions by collision of the moving ions with molecules. Hence under certain conditions the conductivity increases faster than the current, and therefore the product of current and instantaneous resistance decreases. But this last product is a measure of the potential difference of the electrodes. This takes place in the electric arc. Accordingly, an increase of current through the arc is accompanied by a decrease of potential of the carbon electrodes, as experiment shows.

The increase of conductivity over that of the current no doubt chiefly takes place in the layers of carbon vapour close to the electrodes, because there the electric force is largest and the ions have their greatest velocity. Experience shows that it takes place most effectively with short arcs when formed in air between carbon electrodes.

It is also most pronounced with small arc current density, as with large currents any additional ionisation by collision becomes less important. This is clearly shown by the increase of slope of the current-voltage characteristic curve with decrease in the arc current.

If the arc is being formed between solid carbons in air, then, owing to the interpenetration of the carbon vapour by oxygen atoms and the affinity of these for negative electrons forming negative oxygen ions, there is an action tending to deplete the arc of ions which keeps down the rate of increase of conductivity with current. Hence the characteristic curve then never has a very steep downward slope.

If, however, the arc is surrounded and

(3) See W. Duddell. *Journ. Inst. Elec. Eng.; Lond.* Vol. 30, p. 232. 1900.

interpenetrated by hydrogen, then this depletion does not occur, and, on the contrary, the ions obtain a greater mobility which facilitates further ionisation by collision.

Hence the effect of forming the arc in a hydrogen atmosphere is to steepen the slope of the characteristic curve for given currents, as shown by the experiments of Upson. In place of hydrogen we can use alcohol vapour, petrol, or coal gas with the same result. As a result of the increased steepness of the characteristic curve we are able to obtain oscillations of considerable energy when using a shunt condenser of rather small capacity, and hence create oscillations of much higher frequency than when using a carbon arc in air.

The discovery of this fact by V. Poulsen, in 1903, formed the starting-point for fresh important developments in radiotelegraphy. By the employment of a powerful transverse magnetic field of a certain optimum strength, Poulsen found that the arc current could be just extinguished at each oscillation, but would re-light itself if the negative electrode was formed of a carbon rod and remained hot. In this case the R.M.S. value of the alternating current through the condenser may be as much as 70% ($=1/\sqrt{2}$) of the direct current supplied to the arc. We have therefore three currents to consider:

(1) The condenser current (i_s), which is not a purely sinoidal current, but at least has a principal constituent which is a simple harmonic current.

(2) The supply current, I_d, which is a purely direct current, and

(3) The arc current, i_a, which is the sum of I_d and i_s.

If we may, as a first approximation, assume that $i_s = I_s \, sin \, pt$, then in the case of the optimum magnetic field, $I_s = I_d$ $\therefore$ $i_a = I_d \, (1 + sin \, pt)$. The R.M.S. value of $i_a = (I_a)$ is then $I_d \sqrt{\tfrac{3}{2}}$ and $I_d = (I_s)\sqrt{2}$. Hence $I_a = (I_s)\sqrt{3}$ and $I_d = (I_s)\sqrt{2}$. We can therefore represent the R.M.S. values in the optimum case, of the arc current, the shunt current, and the direct current by the sides of a right-angled triangle whose lengths are respectively $\sqrt{3}$, 1, and $\sqrt{2}$.

The optimum magnetic field H_0 which produces this result depends on the frequency of the oscillations. If λ is the wave length, then, according to P. O. Pedersen(4), $H_0 = \dfrac{a}{\lambda} - b$ where a and b are constants. L. F. Fuller gives the formula $H_0 = K\sqrt{P}/\lambda$ where P is the power given to the arc and K depends upon the vapour or gas in which it is formed. K is larger for alcohol than for kerosene vapour. The optimum field is smaller in the case of hydrogen, because the high molecular velocity assists disionisation, and since kerosene and volatile hydrocarbons dissociate into hydrogen and solid carbon whilst alcohol furnishes carbon dioxide, hydrogen and carbon, it follows that the optimum field with alcohol must be stronger than for kerosene or petrol vapour. For a power of 50 K.W. and wave lengths of 7,000 metres the arc in alcohol vapour requires a magnetic field of 8,300 C.G.S. units. For a power of 1,000 K.W. and a wave length of 20,000 metres the field must be 13,500 C.G.S.

Since, however, the iron pole pieces must be kept out of the arc, the air gap is necessarily large, and hence the ampere-turns put on the iron core of the magnet must be large. Thus for large powers the arc generator requires very massive electromagnets and some have been constructed weighing even 80 tons. Great attention has to be paid to the form of the pole pieces.

Transmitting plant on this system consists, therefore, of one or more dynamos capable of supplying direct current at 500-600 volts or more with which arcs are formed between a thick carbon (—) and water-cooled copper (+) electrodes in a chamber kept full of alcohol or kerosene vapour. A powerful magnetic field is maintained transversely to the arc sometimes by the arc currents itself or preferably by a separate dynamo. The arc is shunted by a condenser and inductance, a portion of which latter coil may be in series with the aerial. Signalling is conducted generally by throwing the aerial out of tune with the condenser shunt circuit.

9. There are two restrictive qualities of this arc generator which must be noted. First, the alternating current in the condenser circuit is not of pure sine wave form, and this gives rise to the radiation of other wave lengths besides the fundamental.

In the next place, the efficiency of conversion, even at best, is not high. All those cases of energy transformation in which production of heat is necessary to the transformation have a low efficiency, as, for instance, electric lamps, 5 to 15% thermo-

(4) P. O. Peddersen. *Proc. Inst. Radio Eng.* U.S.A. Vol. 5, p. 255. August, 1917.

piles, etc. If we denote by C the direct current supplied to the arc and by V the potential difference of the carbons, then CV watts is the power given to the arc, neglecting the drop in the regulating resistances. If A is the condenser shunt current and R is the shunt circuit resistance (including radiation resistance), then A^2R is the power given out as alternating current. But with optimum field we may have $A\sqrt{2}=C$ or $\frac{1}{2}C^2R$ is the high frequency power. Then the efficiency $e = \frac{1}{2}\frac{CR}{V}$.

If we denote the direct current resistance of the arc by R_d, then $R_d = \frac{V}{C}$ or $e = \frac{1}{2}R/R_d$.

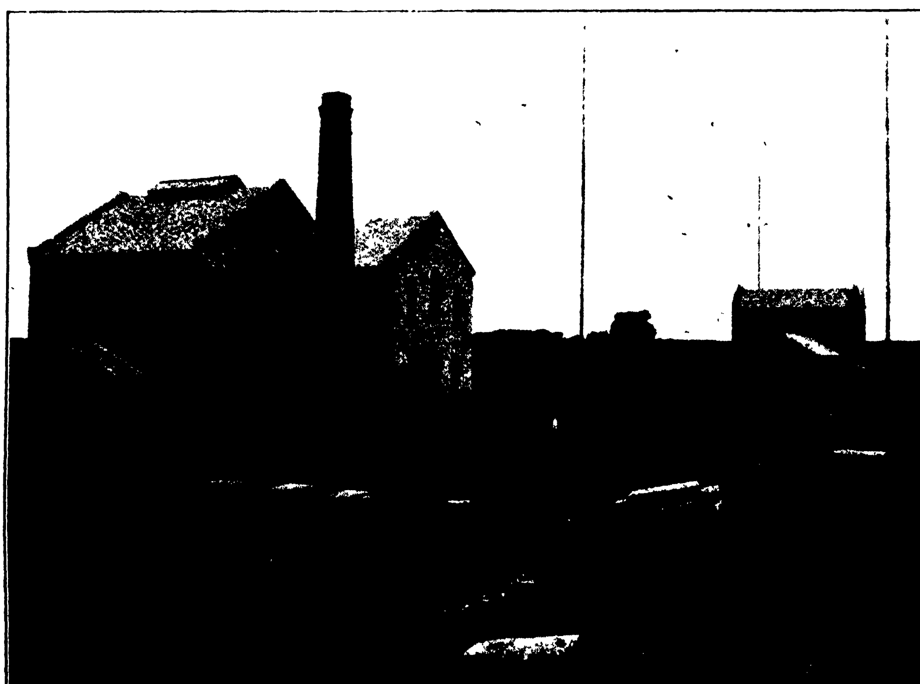
Now R_d is nearly always greater than R, and hence the efficiency can at best approximate to 50%, and is generally less. One other disadvantage must be noted which, however, is, I believe, being overcome, viz., that the power continues to be expended on the arc whether signals are being sent or spaces, as the arc cannot be extinguished and re-lit suddenly.

Nevertheless, the fact remains that the arc method of wave generation has been very extensively used in the last few years for radio work over some of the longest ranges of 3,000, 4,000 or 5,000 miles. It has been adopted for the new G.P.O. station at Leafield, near Oxford, one of the Imperial Wireless Stations working with the station at Abu Zabal, near Cairo (2,239 miles). (See Figs. 3 and 4.) Arc generators of 1.000 K.W. power have been provided for the Croix d'Hins radio station near Bordeaux, France, erected by the American Army, and the results of their operation are awaited with great interest.

IV. The High Frequency Alternator.

10. We must then retrace our steps for a third time over this 21-year period to note the stages of development of a third type of electric oscillation generator, viz., the high frequency alternator.

The earliest workers in this subject who attempted to build alternators with moving coil fields or armatures found difficulties in getting beyond a frequency of 10,000 or so.



By permission of The Post Office Electrical Engineers' Journal and Mr. E. H. Shaughnessy.

Fig. 3.—General view of the Buildings and Aerial of the first Imperial Wireless Station at Leafield, Oxfordshire. Opened August, 1921.

By permission of The Post Office Electrical Engineers' Journal and Mr E H Shaughnessy.

FIG 4 —View of one of the Elwell-Poulsen 250 K W. arc generators, as used in the Imperial Wireless Station at Leafield, Oxfordshire

R. A. Fessenden built in 1907 some small alternators of Mordey type driven by De Laval steam turbines, but E. F. W. Alexanderson in 1908 directed his attention to the production of a high frequency inductor alternator which has now been made in sizes up to 200 K.W. and for frequencies 20,000 to 100,000 or more. This alternator has been so often described that it is not necessary here to give details. The inductor is a steel disc with its edge cut into teeth, the spaces being filled in with non-magnetic material. These teeth pass between the pole teeth of the field magnet and armature winding, and by varying the magnetic induction through the armature give rise to the induced current. All the stator teeth on one side are of the same polarity, so magnetic leakage is absent. The air gap on each side of the armature is less than 1 mm., hence very special means are required for centering and keeping centered the inductor disc. The chief difficulty in connection with H.F. alternator working is the regulation of the speed. Since a variation of $\frac{1}{4}\%$ in the speed of the 200 K.W. machine would cut down the aerial current to half, it has been necessary to devise arrangements for keeping the speed constant within 0.1%, and this feat has actually been achieved.

11. An important item in connection with this control is the so-called magnetic amplifier, which is a type of choking coil of which the choking power or inductance can be varied over wide limits by more or less magnetizing the iron core by a small direct current. The control of the speed is carried out as follows: —One of the coils of the alternator supplies current to a resonant circuit tuned to a frequency a little below that of the aerial. Part of this current is rectified and made to supply the direct-current control of chokers made as above described, which are inserted in the circuit of the current supply of the 2-phase motor which drives the alternator. If, then, the alternator quickens up its speed, this puts the resonant circuit more out of tune, the saturation current of the chokers is made smaller and their inductance larger, and this checks the speed of the driving motors and brings back the alternator to normal speed.

The same type of variable choker is used

in signalling. The current from the alternator armature passes into the primary coil of an air-core transformer. The secondary circuit is in connection with the aerial and the earth. There is also a tertiary circuit between the two which is closed on a variable choker. If the impedance of the latter is high nearly all the power goes into the aerial, but if the choker core is magnetically saturated by a small direct current, then the tertiary circuit is in effect closed and the power passes into it instead of the aerial. Hence the manipulation of a very small direct current by an automatic key enables a large aerial current to be controlled and signals sent at 100 or more words a minute. Ten alternators of this kind of 200 K.W. size are being installed in the new very large radio station for world-wide working being established by the Radio Corporation of America on Long Island, U.S.A. Alternators of this type have been for some time in use in the United States Naval Radio Station at New Brunswick, New Jersey, U.S.A. Two 200 K.W. alternators of the same kind have been installed in the Marconi Company's large station at Carnarvon, in North Wales, and are working the telegraphic traffic to the United States.

12. A few words must then be said on the Homopolar inductor alternators of MM. Latour and Béthenod. In this case the stator part of the machine is not unlike that of Alexanderson. A circular magnetizing coil is embraced by a saddle-sectioned iron ring in the edges of which are fixed teeth of finely laminated iron All the teeth on one side are therefore N. poles and on the other S. poles. An armature winding is laid on zig-zag around the teeth. In the centre revolves a drum rotor with laminated iron rings on its periphery which are ploughed out into ridges. These ridges serve to complete the magnetic circuit of the teeth and so vary the flux through the armature coils. In an ordinary inductor alternator there are twice as many teeth on the stator as on the rotor in the circumference. If there are m rotor teeth and the speed is N R.P.M., then the frequency will be $f = mN/_{60}$. The peculiarity of this French alternator is that there are $(2n+1)m$ teeth in the rotor and $2m$ in the stator. Hence the frequency $f=(2n+1)mN/_{60}$. If $n=1$, then there are $3m$ teeth on the rotor and $2m$ on the stator, and we therefore increase the frequency three times without decreasing the pitch of the stator teeth or raising the speed of the rotor.

Another special feature is that these alternators are enclosed in an air-tight case and run in a vacuum to reduce windage losses due to air churning. In the 220 K.W. alternator the rotor is a steel drum having on it rings of silicon steel 0.03 mm. thick, which are ploughed out in longitudinal grooves. The rotor is 1 metre in diameter and runs at 3,000 R.P.M. This gives 300 periods per revolution, corresponding to a periphery of 314 cms. Hence the pole pitch on the stator is 5 mm., which gives ample space. The rotor is driven by a D.C. motor of 375 K.W. power. The armature is in four sections and the voltage is stepped up by an air core transformer. The signals are made by short circuiting the armature coils.

Alternators of this type of 25 K.W. size are installed in the Lyons Radio Station and a number of 220 K.W. machines are being put in the very large radio station the French Government are completing at St. Assise, near Paris. The Latour-Béthenod alternators above described of the 220 K.W. size are said to have an efficiency of 58% ratio of output on H.F. side to driving power on the rotor. Later machines of 500 K.W. size are said to have 67% efficiency. The frequencies of these larger sizes are 15,000 to 20,000, or for wave lengths of 20,000 to 15,000 metres. A high power radio station equipped with these machines would resemble very closely an electric lighting or power station, with the difference that whereas the latter supplies low frequency currents to underground mains, the former supplies high frequency currents to overhead aerial wires. In many ways the H.F. alternator is an ideal method of generating long electric waves for radio working, and the operations of the new glare alternator radio stations will be watched with great interest. By placing suitable condensers in series with the alternator to reduce their internal reactance, the French engineers have been able to run two or more of these H.F. alternators in parallel on the same aerial. The condenser serves to reduce the reactance and therefore increases the synchronizing power of the machines.

Space does not permit of any reference to the Goldschmidt internal cascade or internal reactive H.F. alternator, which was one of the earliest of the H.F. alternators built for any large power.

In view of the great advances in the simple inductor alternators, it is hardly likely that the more complicated internal cascade alternator will be much used in the future outside perhaps of Germany.

V. The Thermionic Oscillation Generator.

13. We must now make a brief reference to the fourth type of electric wave generating appliance which has been developed in the last eight years, in many respects, scientifically speaking, the most interesting of all, viz., the thermionic transmitting valve. So much has been written on it that it is unnecessary to spend a moment in explaining its principles or history.

The great importance of the valve lies in the fact that it is a reversible engine in a thermodynamic sense of the word, and can act both as an amplifier and detector of oscillations, or conversely as an oscillation generator. Its action depends on the copious emission of electrons from an incandescent tungsten filament or from a platinum wire coated with oxides of barium, calcium or strontium. The electron emission may amount to as much as an ampere per square cm. of surface. This electron stream is made to pass from the hot cathode to a cold anode cylinder. In the so-called three electrode form it passes through apertures in a grid or network. The potential of this grid is one factor which determines the resulting electron current, and the appliance is made to act as a generator by a coupling of the grid and plate circuits so that increase in plate current gives a positive potential to the grid and decrease a negative potential. The oscillations then are created in the anode circuit, provided certain conditions are fulfilled, and their energy maintained by a source of direct E.M.F. in the anode circuit. Hence to obtain large power output we have to provide large cathode surface, which implies a large heating current and therefore a large bulb. Owing to the fragility of glass large bulbs made of silica have been to some extent used. We have then to provide a high direct potential to drive the electrons from the hot filament electrode to the anode cylinder, and this is usually done by stepping up a low voltage low frequency alternating current by a static transformer to 5,000 or 10,000 volts or more and then rectifying this current by one or more two-electrode (Fleming) thermionic valves. A number of these oscillating electron tubes can be worked in parallel and supplied with anode potential from a battery of rectifying valves. Such arrangements are now called a valve panel, and there is no great difficulty in supplying in this manner 150 K.W. to an aerial circuit.

The resulting oscillations are of very pure sine wave form and hence give very sharp tuning.

By suitable proportioning of the circuits it is found that efficiencies as high as 75% or more have been obtained, thus putting the valve efficiency at its best on a level with that of the high frequency alternator and higher than that of the arc generator.

Again, owing to the fact that the grid currents are extremely small, the control of large aerial currents created by valve generators is much facilitated, and there is hardly any practical limit to the speed of signalling with valve transmitters as far as the transmitting appliance is concerned. Furthermore, power expenditure is greatly arrested in the interval between signals, as the anode current is then cut down to zero. In the Report presented to Parliament in June, 1920, by *The Imperial Wireless Telegraph Committee* of 1919-1920 the advantages of valve transmitters were strongly emphasised and their adoption recommended for long-distance Imperial radio stations.

The Marconi Company have recently installed a large panel of generating valves at their Clifden station, which replaces the spark transmitter there formerly used. This panel comprises 12 valves of type MT2, each of 5 to 7 kilowatts capacity. The bulbs are about 7 inches in diameter and 12 inches long. The filaments take 10 amperes at 20 volts for heating, and the anodes are kept at a high potential of 10,000 to 20,000 volts by high tension direct current dynamos run in series. The anode current is about 200 milliamperes at 10,000 volts anode potential.

Using 9 valves, the total anode current is 3.5 amperes for all the valves in parallel with anodes at 18,000 volts. Hence the total feeding power is then 62 kilowatts; including the filament heating power. Such a valve panel conveys to the aerial 47.3 kilowatts, and an aerial current of 260 amperes, assuming a total aerial resistence of 0.7 ohm. This gives a valve efficiency of nearly 75%.

A full description of this valve generator at Clifden was given by Mr. H. J. Round,

in the *Radio Review* for September, 1921. This transmitter gives a very pure sine wave with sharp tuning and strong signals at the receiving stations in Canada and the United States. The success of this plant decided the Marconi Company to instal a still larger valve transmitter of 56 MT2 valves at Carnarvon, which is giving very remarkable and interesting results. Aerial currents up to 350 amperes have been obtained, equivalent to 160 kilowatts put into the aerial.

The engineers of the Company are confident that, with some additions, there should be no difficulty in obtaining aerial currents of 1,000 amperes or more, with a valve transmitter sufficient no doubt for good direct commercial radio-telegraphy to the antipodes.

These facts will show that the future of the valve transmitter is assured. In addition to much less capital outlay than is required for equivalent high frequency alternator or arc plant, there is no necessity for complete duplication to secure reliability, as it is most unlikely that all the valves would fail at once.

VI. Radiative Efficiency of Antennæ.

14. In connection with all long-distance transmission a question of great importance is that of the radiative efficiency of aerials.

The aerial wire at a transmitting station may be likened to the filament of an incandescent lamp in this respect, that we expend electric power upon it but obtain from it only a fraction of that power in the form of radiation of a desired wave length. The bulk of it is dissipated as heat in the circuits. The form of the aerial is therefore of great importance when we are dealing with large power, because we can thereby regulate the fraction of the power which is dissipated. The radiation resistance (r) of an aerial is generally defined as that numerical quantity by which the square of the aerial current at the base must be multiplied to give the useful radiation in watts. The frictional resistance (R) multiplied by the square of the aerial current gives the power dissipated as heat. Hence the aerial efficiency is $r/(r+\mathrm{R})$. In the earliest days of wireless telegraphy this aerial efficiency was not much above 2 or 3%, but the demands of long-distance working have been the means of bringing about great improvements in this respect.

The efforts of inventors have been directed to the reduction in the ohmic or frictional resistance of the aerial and of the earth plate or balancing capacity, which is the chief cause of inefficiency.

One method by which an improvement has been made is the multiple antenna of Mr. E. F. W. Alexanderson. If we consider a horizontal Marconi directive aerial with terminal down lead wires and tuning coil at one end earthed through a generator, the frictional resistance would be partly in the tuning coil and leads, but also in the earth wires and earth itself.

The radiation resistance of such a flat-top aerial can be approximately calculated from the formula $r=1600h^2/\lambda^2$ where h is the effective height of the horizontal part above the earth and λ is the wave length. Since the frictional losses increase as the square of the aerial current, they rise very rapidly with increase of aerial capacity. In the multiple aerial the horizontal part is earthed through several, say, n, other inductive down leads. The voltage generator is placed in one down lead, and the result is that currents flow in all the other down leads in step with that in the first. We may therefore regard the total aerial current as divided between n down leads each of equal resistance, or as flowing through a joint down lead resistance of $1/n$th of a single one. Therefore the radiation efficiency is increased from $r/(r+\mathrm{R})$ to $r/(r+\mathrm{R}/n)$. Thus, for instance, a certain directive aerial at the New Brunswick Station, U.S.A., had originally a single earth connection. Its radiative resistance was about 0.1 ohm and frictional resistance about 3.7 ohms. Hence its radiative efficiency was about 2.7%. By adding to it 6 suitable inductive down leads each of 0.6 resistance with earth resistance of 2.0 ohms each having a radiation resistance of 0.07 ohm, the aerial efficiency was raised to $14\%=.07/(.07+\frac{2.6}{6})$. This was for a wave length of 13,600 metres. By tuning for 8,000 metres the radiative efficiency was raised to 30%. The gigantic radio station now being erected on Long Island, U.S.A., by the Radio Corporation of America, is to have 12 such directive multiple earthed aerials, each 2 kilometres long, arranged like the spokes of a wheel, for transmission and reception in various directions. The oscillations in them will be generated by Alexanderson high frequency alternators of 200 K.W. power. The Polish Government are stated

to have had a contract for a similar large radio station at Warsaw to correspond with the above Long Island Station. Further information on this multiple antenna will be found in an article by Mr. E. F. W. Alexanderson in the *Proceedings of the Institute of Radio Engineers*, U.S.A., for August, 1920, vol. 8, p. 263, on Trans-Oceanic Radio communication.

The Research Department of Marconi's Wireless Telegraph Company has recently developed another highly ingenious method of reducing the frictional resistance of an aerial and so increasing its radiative efficiency. This method they call an "Earth Screen Counterpoise." The following data have been furnished by Mr. H. J. Round, for the Clifden Aerial. This aerial has an effective height of 100 feet, and with the original earth plates, a total resistance of 4.5 ohms. With a wave length of 5,700 metres, it had a radiation resistance of 0.05, and, therefore, a radiation efficiency of 1%. When the earth screen was put in, it reduced the frictional resistance of the aerial to 0.6 ohm; hence, it increased the radiation efficiency to 8%. This aerial is of the directive type, but of very low height. If the height were increased to 100 meters, the result would be a still greater increase in the aerial efficiency to nearly 40%.

Further details will be found in an article by Mr. H. J. Round in the *Radio Review* for September, 1921.

VII. Reception of Wireless Signals.

15. As regards the reception of radiotelegraphic signals, the remarkable discoveries and inventions in the last 17 years in connection with the thermionic valve have made all other types of detector completely antiquated. The properties of the three-electrode valve or triode in respect of amplification and the astonishing sensitivity bestowed on it by re-active and cascade coupling have revolutionised in the last few years the detection of wireless waves. Its present development is due to the inventions and discoveries of numerous investigators of the first rank, and it is difficult for radio-engineers of to-day to put themselves back in thought to the limitations as regards reception existing in pre-valve days. There seems hardly any limit to the variety of ways in which the valve may be used as a wave-detecting device, and as these are now fully described in numerous text books it is quite unnecessary to occupy time here by any repetitions. Signals sent from large radio stations can now be detected even at the Antipodes. The real trouble is not to detect the signals but to avoid amplifying at the same time in the same proportion the noises in the telephone due to the natural vagrant waves referred to particularly in a later section.

The direct aural reception by telephone, combined with the use of either high group frequency or high beat frequency in C.W. reception, has the advantage that the skilled operator can take down signals even on a background of disturbing noises due to atmospherics provided it does not exceed a certain degree.

The speed of such reception is, however, limited to 20-30 words a minute more or less.

Automatic recording of various kinds has therefore been invented. We may register photographically on a sensitive film by the use of an Einthoven galvanometer, and the film or strip can be passed through baths, developed, washed, fixed, and dried within a very short time of registration. Or the signal currents can be made to operate the cutting tool of a gramophone or dictophone and record on soft wax cylinders or dics at a high speed, say, 100 words a minute. The disc or cylinder can then be run through a repeating machine slowly, so that a clerk can take down the letter signals as heard and typewrite them instantly.

Furthermore, the old Bain electro-chemical telegraph with chemically prepared paper strip has been revived and the signal currents amplified and rectified by valves can be made to record at astonishing speeds even 400 words or more a minute on the tape. A type of recorder very largely used is one called an Undulator, a sort of syphon recorder in which a pen writes on paper strip square-shouldered notches, short or long, for dots and dashes. It is operated by a rectified amplified valve current.

Finally, by the use of mechanical relays printing telegraphs, such as the Creed Printer or Murray Printer, can be actuated and the letter signals recorded on tape or page form in Roman type, as shown here by Mr. Campbell Swinton not many months ago in this theatre. The oscillation generating properties of the three-electrode valve have made beat or heterodyne reception of continuous waves a simple practical matter, and the receiving operator has

perfect control over the beat frequency to suit himself. In fact, it is the thermionic valve which has made C.W. radiotelegraphy possible at all with certainty and speed. Then again, the immense sensitiveness of valves in series has made it possible to receive over long distance on quite small frame aerials which have directive properties of reception. This assists in cutting out disturbances from other stations and in some degree mitigates the troubles with atmospheric discharges. It also renders quite simple duplex transmission, and it is now the usual thing in long-distance radiotelegraphy to establish the receiving station some miles away from the associated transmitting station and to take up the signals from the distant transmitting station on suitably placed frame aerials, so that sending and receiving go on together. As regards reception, the chief unsolved problem is that of cutting out the atmospherics, which are the chief cause of the necessity for frequent repetitions of messages and words, and therefore of uneconomical delays in transmission.

(*To be continued*)

OBITUARY.

THE RIGHT HON. FREDERICK HUTH JACKSON.—The Right Hon Frederick Huth Jackson, who was elected a Life Fellow of the Royal Society of Arts in 1918, died at his residence, Tossingworth, Cross-in-Hand, Sussex, on the 3rd inst.

He was born in 1863, and educated at Harrow and Balliol. On leaving Oxford he began to read for the Bar, but he was offered and accepted a clerkship in the famous firm of merchant bankers, Frederick Huth & Co.; he soon became a partner, and shortly afterwards was elected a director of the Bank of England, at a younger age than any previous recipient of that honour.

Mr. Huth Jackson was Chairman of the Indemnity Mutual Marine, a director of the Eastern Telegraph Company, the Northern Assurance Company, and the London and South-Western Railway; and at one time he was Chairman of the Anglo-Chilean Nitrate and Railway Company. From 1909-11 he was president of the Institute of Bankers. He was also president of the National Alliance of Employers and Employed, and he took the chair at the meeting of the Royal Society of Arts in 1918, when a paper on "The Foundation of Industrial Peace" was read by Mr. A. H. Paterson, Secretary of the Alliance.

He was one of the British delegates at the Hague Conference on bills of exchange, and he took an active part in the discussion that led to the moratorium. He was also chairman of the Accepting Houses Committee, and worked energetically in the negotiations regarding the pre-war indebtedness of enemy aliens; while later on he acted as treasurer of the Vienna Relief Fund.

He was created a Privy Councillor in 1911.

TRADE IN PERSIAN LAMBSKINS.

According to data supplied by the All-Russian Central Union of Consumers' Societies, Bokhara is the most important city in the Persian lambskin trade. The producers bring these lambskins to the bazaars of Bokhara in boxes containing from 50 to 100 skins, where they sell them to the large jobbers, who boil and dry them by special methods, which constitute the first process of preparation

Prior to the War, the most important markets for skins in this form were Moscow and Nizhni-Novgorod where they were bought by large Russian furriers and foreign firms The most important of these foreign firms interested were the German firms, which shipped the skins to Leipzig, where special establishments for finishing furs are found.

It appears from a memorandum on this trade, prepared by the Russian Division of the M.S. Bureau of Foreign and Domestic Commerce, that there are three grades of lambskins according to quality.

(1) The best skins come from Bokhara and are distinguished by the thin skin, large dimensions, and small and beautifully arranged curls of splendid lustre.

(2) The skins from Khiva and Afghanistan are inferior, as the hides are thicker and the curls larger.

(3) The skins from Persia, owing to the small dimensions of the skins, their lack of lustre and curls, and their inferior durability make up the poorest grade.

The Persian lambskins from Bokhara are chiefly used for clothing purposes, as jackets and overcoats These are divided into four grades. The first is distinguished by large curls. The second has small curls in a velour effect, and is mainly used for overcoat collars and capes. The third is called "Kupuc," constituting 5 to 10 per cent. of each bundle when purchased. The fourth grade is named "Karakulch," consisting of hides from still-born sheep and are of small dimensions, having thin skins and small curls. Although the last grade is sold in Russia at prices from 30 to 35 per cent. cheaper than the other grades, the markets of Western Europe and America sell them at prices considerably higher.

Before the War, 2,000,000 to 2,500,000 skins were handled at Bokhara. During the War this number greatly decreased because the borders of the Russian Empire were closed for export. As a result, trade fell off. Prior to 1917, all skins were shipped to the interior of Russia,

but after that year there were no regular shipments.

As a result of this curtailment of shipping there were in June, 1920, estimated accumulations at Bokhara as follows: 1,200,000 skins of 1917; 700,000 skins of 1918; 400,000 skins of 1919; and 200,000 skins of 1920; making a total of 2,500,000 skins.

Beginning with the year 1919 the shipment of furs to Western Europe practically ceased, owing to the poor facilities on the railway between Orenburg and Tashkent. The interruption of the sea route between Krasnovodsk and Astrakhan was also detrimental to this trade.

MEETINGS OF THE SOCIETY.

Ordinary Meeting.

Wednesday evening, at 8 o'clock.

December 14.—Sir Walter Beaupre Townley, K.C.M.G., Minister to the Netherlands, 1917-19, "Trade with the Netherlands East Indies." The Right Hon. Lord Emmott, G.C.M.G., G.B.E., will preside.

Papers to be read after Christmas:—

Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

Howard Maurice Edmunds, "Photo Sculpture."

Cloudesley Brereton, M.A., Divisional Inspector to the London County Council (Modern Languages), "The Necessity of Speech Training, and the Need of a National Conservatoire."

Philip Schidrowitz, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

John Francis Crowley, D.Sc., B.A., M.I.E.E., "Electrical Driving in the Jute Industry."

W. A. Appleton, C.B.E., Secretary to the General Federation of Trade Unions, "The proper Function of Trade Unions."

Edward Victor Evans, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry."

Alexander Scott, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum."

Arthur Wilcock, "Surface Printing by Rollers in the Cotton Industry."

George Fletcher, Department of Agriculture and Technical Instruction for Ireland. "The Natural Power Resources of Ireland."

J. H. Huxley, "The Control of Sex in Animals."

Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in relation to Industrial Hygiene" (Shaw Lecture).

Professor Ernest R. Matthews, Assoc.M.Inst.C.E., "Sea Encroachment and its Prevention."

Professor Arthur P. Laurie, M.A., D.Sc., F.R.S.E., "The Permanency of Oil Colours."

J. T. Marten, I.C.S., M.A., "The Indian Census" (Indian Section).

Alexander L. Howard, "The Timbers of India and Burma." (Indian Section.)

Professor William Arthur Bone, D.Sc., Ph.D., F.R.S., "Brown Coals and Lignites: Their Importance to the Empire." (Joint Meeting, Dominions and Indian Sections.)

Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India" (Indian Section).

F. G. Royal Dawson, M.Inst.C.E., Chief Engineer to Indian Railway Board. "The Need for an All-Indian Gauge Policy." (Indian Section.) Sir Henry Parsall Burt, K.C.I.E., C.B.E., will preside.

Professor Sir Thomas W. Arnold, C.I.E., Litt.D., M.A., Hon. Fellow of Magdalene College, Cambridge, *Sir George Birdwood Memorial Lecture.* (Indian Section.)

Lieut.-Colonel Sir Thomas Bilbe Robinson, G.B.E., K.C.M.G., "Queensland." (Dominions and Colonies Section.)

Cantor Lectures.

At 8.0 p.m.

Mondays.—Arthur M. Hind, O.B.E., M.A., Assistant-Keeper, Department of Prints and Drawings, British Museum, and Slade Professor of Fine Art in the University of Oxford, "Processes of Engraving and Etching." Three Lectures.

Syllabus.

Lecture III.—December 12.—Etching.—The Process and its Origin—Survey of work by the great original Etchers: Rembrandt, Van Dyck and others—Examination of the special qualities of Etching in relation to different kinds of work—Recent Etching.

C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." Three Lectures. January 23rd, 30th, and February 6th.

ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington. "The Mechanical Design of Scientific Instruments." Three Lectures. February 20, 27, and March 6.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constitutents of Essential Oils." Three Lectures. March 20, 27, April 3.

COBB LECTURES.

At 8.0 p.m.

MONDAYS, F. F. RENWICK, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MANN JUVENILE LECTURES.

At 3.0 p.m.

WEDNESDAYS, JANUARY 4 and 11, 1922, WILLIAM REGINALD ORMANDY, D.Sc., "Clay: What it is—Where it comes from—and What can be done with it."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, DECEMBER 12 .. University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "Recent Researches on the Biology of Bacteria." (Lecture I.)

Geographical Society, Kensington Gore, S.W., 5 p.m. Mr. F. Dixey, "Photographic Equipment and Methods of Travellers."

Surveyors' Institution, 12, Gt. George Street, S.W., 8 p.m.

Alpine Club, 23, Savile Row, W., 8.30 p.m.

Victoria League, 22, Eccleston Square, S.W., 5 p.m. Mr. C. Henshaw, "The Rocky Mountains of Canada."

East India Association, at Caxton Hall, Westminster, 3.30 p.m. Dr. John Pollen, "The Liquor Question in India."

TUESDAY, DECEMBER 13 .. Petroleum Technologists, Institution of, at the ROYAL SOCIETY of ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. A. F. Dabell, "Better Production Methods."

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. W. J. Sandeman, "Progress of Gas Lighting in relation to Illuminating Engineering."

Photographic Society, 35, Russell Square, W.C., 7 p.m. (Technical Meeting).

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Mr. Campbell-Thompson, "Modern Babylonia."

Civil Engineers, Institution of, Gt. George Street, S.W., 6 p.m.

University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "Recent Researches on the Biology of Bacteria." (Lecture II.)

British Decorators, Institution of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. S. Hicks, "Art in Modern Education."

Anthropological Institute, 50, Gt. Russell Street, W.C., 8.15 p.m.

Chemical Industry, Society of, and the Chemical Industry Club (Joint Meeting), at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. The following kinematograph films will be shown:—1. The Winning and Working of Sulphur. 2. The Manufacture of Steel (Crucible, Open Hearth, Electric and Bessemer Processes.) 3. The Metallurgy of Zinc.

Faraday Society, at the Chemical Society, Burlington House, W., 7.45 p.m. 1. Annual General Meeting. 2. Prof. A. O. Rankine, "The Structure of Some Gaseous Molecules."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Mr. G. E. Fleming, "White Metals."

Electrical Engineers, Institution of (Scottish Centre), 207, Bath Street, Glasgow, 7.30 p.m. Messrs. L. J. Steele and H. Martin, "The Cyc-Arc Process of Automatic Electric Welding."

Textile Institute, 16, St. Mary's Parsonage, Manchester, 4 p.m. Mr. H. Rostrow, "Continued Education."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir Charles Lucas, "Balance of Power within the Empire."

WEDNESDAY, DECEMBER 14 .. Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Dr. H. F. L. Croutt, "Motor Car Gear Boxes."

Microscopical Society, 20, Hanover Square, W., 8 p.m. 1. Mr. F. A. Smith, "The Microscope in Non-Ferrous Metallurgical Research." 2. Drs. J. G. Parker and S. H. Browning, "The Practical Value of the Microscope in Connection with Leather Manufacture."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 4.15 p.m.

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. H. G. Williams, "The Cost of Living and its Implications."

United Service Institution, Whitehall, S.W., 3 p.m. Colonel R. N. Harvey, "The General Effect of the War in the Principles and Details of Field Engineering."

THURSDAY, DECEMBER 15 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Captain F. M. Green, "Development of the Fighting Aeroplane."

University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "Recent Researches on the Biology of Bacteria." (Lecture III.)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Mr. L. H. A. Carr, "Induction-Type Synchronous Motors."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m., Mr. E. F. Sargeant, (a) "The Preparation of Concrete Aggregates." (b) "Moving Forms."

Child-Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Miss Von Wyss, "Vital Elements in Art Teaching."

Camera Club, 17, John Street, Adelphi, W.C., 8.15 p.m. Mr. F. F. Renwick, "The Action of Dyes in Colour Sensitising and Desensitising Dry Plates."

Antiquaries, Society of, Burlington House, W., 8.30 p.m.

Architects, Society of, 28, Bedford Square, W.C., 6 p.m.

FRIDAY, DECEMBER 16 .. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. J. Paterson, "The Operation of a Road Distributing Agency."

Metals, Institute of (Local Section), The University, Sheffield, 7.30 p.m. Mr. A. G. Lobley, "Electric Furnaces."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. 1. Mr. R. E. Knight, "Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators." 2. Mr. G. Mitchell, "Conveying and Elevating Machinery."

Photographic Society, 35, Russell Square, W.C., 8 p.m. Address by Mr. L. Richmond.

Announcements intended for insertion in this list must be received at the Society's Office not later than the Monday of the week preceding the meeting.

*For Meetings of the Royal Society of Arts, see page 65.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

SIXTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 7th; HIS EXCELLENCY THE BELGIAN AMBASSADOR in the Chair.

The following candidates were proposed for election as fellows of the Society:—

Hopkins, James Love, LL.B., St. Louis, U.S.A.
Ruddick, James, Quebec, Canada.

The following candidates were balloted for and duly elected Fellows of the Society:—

Ams, C. A. M., Calcutta, India.
Ellis, Alec R., Liverpool.
Keller, George J., Bloomsburg, Pa., U.S.A.
Kutar, Kekobad Rustomji, Bombay, India.
Lewis, Samuel Judd, D.Sc., F.I.C., Ph.C., London.
McCutcheon, Robert Thomson, F.S.A.A., Glasgow.

A paper on "Literature and International Relations" was read by M. EMILE CAMMAERTS.

The paper and discussion will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

On Monday evening, December 12th, MR. ARTHUR M. HIND, O.B.E., M.A., Slade Professor of Fine Art in the University of Oxford, delivered the third and final lecture of his course on "Processes of Engraving and Etching."

On the motion of the Chairman, a vote of thanks was accorded to Professor Hind for his interesting course.

The lectures will be published later on in the *Journal*.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry," by SAMUEL JUDD LEWIS, D.Sc., F.I.C., have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been reprinted and are still on sale can also be obtained on application.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 4th and 11th January, 1922, at 3 p.m., by Mr. William Reginald Ormandy, D.Sc., F.I.C., on "Clay: What it is—Where it comes from—and What can be done with it." The lectures will be illustrated with experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

CASES FOR JOURNALS.

Cases for keeping the current numbers of the *Journal* are now obtainable. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s*. 6*d*. each, on application to the Secretary.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s.* each. on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, NOVEMBER 23RD, 1921.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

THE COMING OF AGE OF LONG DISTANCE RADIOTELEGRAPHY AND SOME OF ITS SCIENTIFIC PROBLEMS—PART II.

By J. A. FLEMING, M.A., D.Sc., F.R.S.
Albert Medalist of the Royal Society of Arts

FIFTH TRUEMAN WOOD LECTURE.

(*Continued from page 78.*)

VIII. PROPAGATION OF ELECTROMAGNETIC WAVES ROUND THE EARTH.

16. The achievement of transatlantic radiotelegraphy in 1901 and 1902 was of interest to physicists chiefly by reason of the fact that they did not see clearly why it should have been possible at all. The mystery of it was increased when at subsequent dates radio signals were transmitted a quarter of the way round the world, and finally, with high power stations and thermionic valves detected even at the Antipodes.

The wave length of the waves used in the earliest work at Poldhu was about 3,000 feet, although not accurately measured in those days.

The earth, roughly speaking, is a sphere 42 million feet in diameter. Hence the ratio of wave length then used to earth diameter was about 1 : 14,000.

In the case of light there is a small bending or diffraction of the wave round an opaque obstacle. In other words, there is some small amount of illumination within the boundary of the geometrical shadow. The average wave length of light waves is about 1/2,000th of a millimetre, and a sphere having a diameter of 7 mm. would be 14,000 of such wave lengths. Now if an exceedingly small source of light was placed on the pole of a sphere 7 mm. in diameter in a dark region, it is certain that there would be no illumination at the equator of the sphere. In other words, there would not be any sensible diffraction at an angular distance of 90°. Modern long-distance radiotelegraphy conducted with waves of wave length approximating to 10 miles or so can communicate even with the Antipodes.

It therefore became of great interest to consider the question of the diffraction of long electromagnetic waves round a conducting or semi-conducting sphere at the pole of which a Hertzian oscillator was placed with the axis radial. The object of the investigation is to find a mathematical expression for the magnetic and electric forces at any point on the surface of the sphere removed from the oscillator by an angular distance θ. The problem is by no means easy and has engaged the attention of many most eminent mathematicians and caused much discussion. It was first attacked by Professor H. M. Macdonald (5) in 1903, but the amount of diffraction which he obtained was relatively large and his results were criticised by the late Lord Rayleigh (6) and by M. Poincaré (7). Macdonald (8) then revised his calculations and found that at large angular distances the diffraction was certainly small. In a subsequent paper Macdonald (9) attacked the problem again and gave numerical results for wave lengths of 0.2 mile (=320 metres) and 0.25 mile (=400 metres) in the form of a table showing the ratio of the amplitude of the oscillations at the receiver to the amplitude at the same point if the earth were supposed removed, for various angular distances. His calculations were, however, made for wave lengths far shorter than now employed, and since the diffraction is greatly affected by wave length these early numerical results are no longer of interest. The subject was then discussed by Prof. J. W. Nicholson (10) in a series of able papers in the *Philosophical Magazine*, and the mathematical treatment led to discussions between himself and Prof. Macdonald.

(5) H. M. Macdonald. *Proc. Roy. Soc.; Lond.* Vol. 71, p. 251. 1903.
(6) Lord Rayleigh. *Proc. Roy. Soc.; Lond.* Vol. 72, p. 40 (1904).
(7) Poincaré, H. *Proc. Roy. Soc.; Lond.* Vol. 72, p. 42 (1904).
(8) H. M. Macdonald. *Proc. Roy. Soc.; Lond.* Vol. 72. p. 59 (1904).
(9) H. M. Macdonald. *Phil. Trans. Roy. Soc.; Lond.* Series A Vol. 210, p. 113 (1910).
(10) J. W. Nicholson. *Phil. Mag.* (Ser. 6), Vol. 19, pp. 516, 757 (1910). Vol. 20, p. 157 (1910), and Vol. 21, pp. 62, 281 (1911).

The numerical results deduced from the formulæ as given by Nicholson and Macdonald (11) respectively do not, however, agree. Dr. Van der Pol (12) has pointed out a small mathematical slip in Nicholson's analysis which, when rectified, brings his formula into better agreement with that of Macdonald for short distances. The problem of the transmission of electromagnetic waves over the earth was next critically discussed by Prof. A. E. H. Love (13) in 1914, and his results compared with Macdonald's conclusions. In the case when the earth is assumed to be a perfect conductor Love found complete agreement between his formulæ and those of Macdonald for the ratio of the magnetic and electric forces at two stated angular distances from the transmitter when these distances reckoned as angles along a meridian are not smaller than 6° or 7° and not greater than about 20°.

17. The mathematical treatment of the problem of the diffraction of electric waves round a conducting sphere which are radiated from a transmitter at its pole consists in expressing the magnetic and electric forces at any angular distance θ in the form of a series of harmonic terms. It is in the summation of this series to obtain the integral effect at the receiver that the chief difficulties and differences of opinion occur, and most analysts employed only an approximation.

In 1918 Prof. G. N. Watson (14) effected a new and complete summation which enables the value of the forces to be calculated for any point on an imperfectly conducting sphere.

The results obtained by Watson are in close agreement with those of Nicholson when the formula of the last-named mathematician is corrected for the slip noted by Dr. Van der Pol (15). The final conclusions can be presented as follows:—Let there be two receiving stations on a meridian at angular distances θ_1 and θ_2 (reckoned in radians) measured from the transmitter station. Let H_1 and H_2 be the amplitudes of the magnetic force at these two stations due to continuous electromagnetic waves sent out from the transmitter.

Then according to Macdonald and Love

$$\frac{H_1}{H_2} = \frac{\cos\frac{1}{2}\theta_1 \sqrt{\sin\frac{1}{2}\theta_2}}{\cos\frac{1}{2}\theta_2 \sqrt{\sin\frac{1}{2}\theta_1}} \, \varepsilon^{47.9\lambda^{-\frac{1}{3}}(\sin\frac{1}{2}\theta_2 - \sin\frac{1}{2}\theta_1)}$$

where λ is the wave length.

According to Nicholson, Van der Pol and Watson

$$\frac{H_1}{H_2} = \frac{\sqrt{\sin\theta_2}}{\sqrt{\sin\theta_1}} \, \varepsilon^{23.9\lambda^{-\frac{1}{3}}(\theta_2 - \theta_1)}$$

The difference between the above formulæ is not large for angles, such that $\cos\frac{1}{2}\theta$ is nearly unity, and under these conditions, which hold when θ_2 or θ_1 do not exceed, say, 20°, or a meridian distance of, say, 2,000 kilometres, we may employ either formula, but for longer distances the second formula is more exact.

As it is more convenient to work with antenna currents than magnetic forces, Dr. Van der Pol has converted the above second formula into another, as follows:—

$$\frac{I_2}{I_1} = 0.5368 \frac{1}{\sqrt{\sin\theta}} \frac{\alpha_1 h_1 \alpha_2 h_2}{\lambda^{7/6} R_2} \, \varepsilon^{-23.9\,\theta\,\lambda^{-\frac{1}{3}}}$$

Here I_1 and I_2 are the ampere currents at the base of the sending and receiving aerials respectively, θ is the angular meridian distance of them in radians, λ is the wave length in kilometres, h_1 and h_2 are the heights in kilometres of the aerials, α_1 and α_2 are form factors giving the ratio of the mean aerial currents to the currents at the base, and R2 is the equivalent resistance (including radiation resistance) of the receiving system reckoned in ohms. The above formula is valid for a perfectly conducting earth surrounded by a perfectly insulating atmosphere.

It is more convenient to measure the distance (d) of the stations in kilometres measured along the earth's surface, and in that case the exponential factor in the last formula becomes

$$\varepsilon^{-0.00376\, d\, \lambda^{-\frac{1}{3}}}$$

18. The result, then, of 18 years' work on this problem by mathematicians of the highest rank has been to give us a formula for the current in a receiving aerial of given resistance determined in terms of wave length, aerial heights and distance which represents the result of pure diffraction acting round a spherical earth of perfect conductivity. On the other hand, when we come to compare the results of this diffraction formula with actual observations in practice we find an enormous discrepancy.

(11) H. M. Macdonald. *Proc. Roy. Soc.; Lond.* Vol. 90, p. 50 (1914).
(12) Dr. Balth Van der Pol *Phil. Mag.* Vol. 38, p. 365 (1919).
(13) A. E. H. Love. *Phil. Trans. Roy. Soc.; Lond.* Series A. Vol. 215, p. 105 (1915).
(14) G. N. Watson. *Proc. Roy. Soc.; Lond.* Series A. Vol. 95, p. 83 (1918).
(15) B. Van der Pol. *Phil. Mag.* Vol. 38, p. 377. September, 1919.

The actual received currents in the case of long-distance stations for given sending aerial currents are hundreds of thousands, or even millions, of times greater than the received current predicted by the theoretical formula.

Thus, to take a case quoted by Dr. Van der Pol from observations made at Darien Radio Station on the Panama Canal on radio signals sent from Nauen, near Berlin. Dr. L. W. Austin gives the following figures: $I_1 = 150$ amps, $\lambda = 9.4$ kilometres, $a_1h_1 = 120$ metres, $a_2h_2 = 146$ metres, $R_2 = 29$ ohms, and $d = 9,400$ kilometres.

Now the actual received current was $I_2 = 1.3$ microamperes, but the value predetermined by the formula is only 0.6 of one millionth of a microampere. In other words, the actual received current in this case is 2 million times greater than the predicted current. Even if there is a large percentage error in the measurement of the received current, this will not make matters much better. Nor will the finite conductivity of the earth's surface account for it. About three-quarters of the earth's surface is sea water, and the absolute conductivity of this for high frequency currents is about 10^{-11}, an electromagnetic unit, equivalent to a specific resistivity of 100 ohms per centimetre cube. Nevertheless, investigations have shown that even this finite conductivity cannot increase the received aerial currents to any very great extent.

The upshot of the whole matter then is this: —Long-distance radiotelegraphy, say, round one-quarter of the circumference of the earth, would certainly be quite impossible but for some cause, other than diffraction, operating to compel the waves to follow round the earth's curvature and not quickly glide off it.

19. Oliver Heaviside in 1900 suggested that an upper conductive layer on the atmosphere might act as a guide to the waves, radiotelegraphy being, in fact, conducted in a thin spherical shell of non-conductive air bounded by a conductive earth and a conductive upper air.

He did not furnish any valid reasons to explain why this upper air conducts and how its conductivity is preserved, and although the suggestion has been very generally accepted by radio engineers, it has been taken without sufficient criticism of its difficulties and details. There has been in the intervening 21 years an immense accumulation of facts, all showing, however, that long-distance radiotelegraphy is conditioned by the physical constitution of our atmosphere and is very far removed indeed from being simple electromagnetic wave propagation in empty space. An important epoch in this connection is the date 1902, when Senatore Marconi (16) discovered during one of his early voyages across the Atlantic in the *s.s. Philadelphia* in February, 1902, that radio signals from Poldhu could be received at night about thrice the distance they could be read in daytime, being detectable only up to 700 miles by day, but readable up to 2,099 miles by night.

It was at once surmised that the difference was due to ionisation of the air by sunlight, which, by liberating electrons from atoms, gives to the air conductivity. It was some years before this vague suggestion was converted by Dr. W. H. Eccles (17) into a more definite scientific theory, many speculations in the meantime being found wanting in adequate basis, such as that which regarded the sunlit air as having an absorption for the energy of electro-magnetic waves similar to that of foggy or misty air for visible light.

20. Before entering into further discussions of the facts, it will be convenient to mention a few of the generally accepted views as to the constitution of the terrestrial atmosphere and its ionisation by light.

By the use of hydrogen-filled sounding balloons carrying self-recording meteorographs, it has been possible to explore the atmosphere up to a height of about 20 miles. One of the results is to show that our atmosphere may roughly be divided into two regions. In the lower layer, called the *troposphere*, the atmospheric gases are kept well mixed up by winds and convection. This layer extends to a height of 6 or 7 miles or so, and in it the temperature falls regularly with increasing height at the rate of about 6°C. per kilometre of ascent until a temperature of about —55°C. is reached. Above this is a zone called the *stratosphere*, of unknown thickness, in which the temperature remains constant. Above a height of about 7 miles water vapour is absent, and at higher levels convection ceases to operate and the atmospheric gases arrange themselves in order of density.

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(16) G. Marconi. *Proc. Roy. Soc.; Lond.* Vol. 70, p. 344 (1902).

(17) W. H. Eccles. *Proc. Roy. Soc.; Lond.* Series A. Vol. 87, p. 79 (1912).

The outer and highest levels above a height of 60 miles (=100 kilometres) are chiefly composed of Helium and Hydrogen with possibly some small admixture of the rarer atmospheric gases Neon and Krypton.

The volume composition of the atmosphere at the earth's surface is as follows:—

Nitrogen	..	78.05%.
Oxygen	..	21.00%.
Argon	..	.93%.
Carbon dioxide	..	.03%.
Hydrogen	..	1 to 10 vols. in a million of air.
Neon	..	10 ,, ,, ,, ,,
Helium	..	1 to 2 ,, ,, ,, ,,
Krypton	..	1 vol. ,, ,, ,,
Xenon	..	·05 ,, ,, ,, ,,

Oxygen is almost entirely absent at a height of 100 kilometres, but nitrogen is still present in a rarified form. The presence of hydrogen and helium at these high levels has been indicated by an observation of Pickering on the spectrum of a meteoric stone entering the earth's atmosphere, which showed the hydrogen and helium lines.

21. Next, as regards the action of light on these gases. Light waves of high refrangibility impinging on nearly all substances, especially those containing electropositive atoms, liberate from them electrons. The atom is now considered to be a collocation of negative electrons arranged in concentric shells, possibly in orbital motion, round a central positively charged nucleus in which the gravitative mass of the atom chiefly resides.

Light of short wave length causes one or more of these negative electrons to be detached and projected with a high velocity. The more electronegative an atom is the higher must be the frequency of the light to affect it. The electrons so detached are called photoelectrons and the action photoelectric.

In the case of sodium or potassium, which are highly electropositive metals, photoelectrons are emitted under the action of visible light, about the middle of the spectrum, but for less electropositive metals, e.g., zinc and magnesium, the action only takes place with ultra violet light. Hence it follows that a plate of zinc illuminated by light from an electric arc or by the spark between aluminium balls loses a negative charge readily, and if insulated, becomes positively electrified owing to the loss of negative photoelectrons. The velocity with which these photoelectrons are projected is considerable, and may be 500 to 1,000 kilometres per second. A certain energy (W) has to be expended to detach an electron from an atom, and if its mass is m and maximum emission velocity v, its maximum kinetic energy will be $\frac{1}{2}mv^2$ and the total energy imparted to it must be $W+\frac{1}{2}mv^2$. It has been found that this total energy is proportional to the light frequency and to a constant, called Planck's Constant ($=6.55 \times 10^{-27}$ C.G.S. units). We can represent this work as the product of a certain voltage (V) called the ionising potential and the electron charge e ($e=4.8\times 10^{-10}$ electrostatic units or $=16\times 10^{-21}$ electromagnetic units). Hence, if we neglect the energy W, which is relatively small, we have the equation,

$$\frac{V\times 10^8 \times 16}{10^{21}} = \frac{6.55\times 3\times 10^{10}\times 10^8}{10^{27}\times\lambda}$$

where V is the ionising potential in volts and λ the light wave length in Angström units (1 A.U. $= 10^{-8}$ cm.). This gives $V\lambda=12{,}000$.

For most metals the ionising potential is about 2 to 4 volts, hence the maximum wave length of ionising light is just beyond the violet end of the visible spectrum. But for atmospheric gases, when pure and free from dust or moisture, the ionising potential is much higher, being approximately as follows:—

Nitrogen	..	..	7.5 volts.
Oxygen	..	..	9 ,,
Hydrogen	..	..	11 ,,
Argon ..	..	..	12 ,,
Neon ..	..	..	16 ,,
Helium	..	..	20.5 ,,

It follows from this that the atmospheric gases cannot be ionised by light of longer wave length than 1,350 A.U. Rays of this short wave length are not transmitted by quartz but only by certain samples of fluorite, and are absorbed by a very small thickness of air. No sunlight of shorter wave length than about 2,950 A.U. reaches the earth's surface, as shown long ago by Huggins and Cornu.

Hence the conclusion is forced on us that pure dust-free atmospheric gases cannot be ionised at the lower levels of the atmosphere by the direct action of sunlight, but at the higher levels above 60 to 100 kilometres doubtless there is direct ionisation.

Nevertheless, ionisation does take place in the lower atmospheric levels, as shown by the small finite electric conductivity possessed by the air, which proves that

there are negative ions, either free electrons, or electrons attached to neutral atoms, and also positive ions present in the air, even over wide oceans. Thus, Boltzmann found in tests made in mid-Atlantic 1,150 positive and 800 negative ions in the air per c.c. A. S. Eve found 600 to 1,400 positive and 500 to 1,000 negative per c.c., the positive ions being slightly in excess.

This ionisation may be produced either by photoelectric action on dust or ice particles in the air, or by radio active matter in the soil, or photoelectric action upon complex gaseous molecules in the air, or generated by the light and called condensation nuclei.

Such agencies, however, cannot account for the far larger and permanent ionisation necessary to give the required electric conductivity in the higher atmosphere if it is to act as a guide to long electromagnetic waves. The conductivity of a gas is related to number of ions and ionic freedom of movement as follows. If there are n_1 positive ions and n_2 negative per c.c., and if the + ions acquire a velocity v_1 cms. per second under an electric force of one volt per centimetre, and the - ions a velocity of v_2, then the total current I through the gas under a voltage V is $I = (n_1v_1+n_2v_2)eV$ where V is the impressed voltage. If we take v_1 nearly equal to v_2 and n_1 nearly equal to n_2, this becomes $I = nveV$ where n is the total number of ions and v their average added velocities under unit electric force respectively. Rutherford found that for air at normal temperature and pressure the value of v is about 2×1.4 cms./sec., or, say, 3 cms./sec., and for hydrogen $v=2\times 3.9=7.8$ cms./sec. Since 1 volt$=10^8$ electromagnetic units, this gives $v=3/10^8$ for air and $e=16/10^{21}$ using electromagnetic units. The ratio I/V is the absolute conductivity, and hence $1/nev$ gives us the specific resistance in electromagnetic units. Supposing, then, that $n=2{,}000$, then we should have

$$2{,}000\times\frac{3}{10^8}\cdot\frac{16}{10^{21}}=\frac{96}{10^{26}}=10^{24}\text{ conductivity}$$

in E.M.U.$=10^{15}$ ohms resistivity.

This would make the specific resistance of the air at normal temperature and pressure about 1,000 million megohms per c.c.

Even if there 10,000 ions per c.c. present, this would only make the specific resistance 50 million megohms per c.c. and hence practically a perfect insulator.

22. A consideration of the terrestrial radiotelegraph problem shows that if there is any conductive layer in the upper atmosphere which can act as a guide to long electromagnetic waves round the earth, it must possess the following properties:—

(1.) It must be permanently ionised, which means that its ionisation must not vanish in the night-time since, as far as we know, its guiding powers are not suspended on the shadow side of the earth. This seems to imply that the ionisation must be predominantly of one sign or that the + and — ions are so far separated that they do not readily re-combine..

True gaseous photo-ionisation always produces ions of both signs in equal number mixed up together and the conductivity quickly disappears when the ionising agency is withdrawn.

(2.) The resulting electric conductivity must be sufficiently high, say, as good as that of ordinary fresh water to act as a true wave guide. This implies that the ions must be very numerous per c.c. and very mobile or have high ionic velocities under unit electric force.

The specific resistance of fresh water is from 1 to 5 megohms per centimetre cube more or less. That of sea water about 20 to 100 ohms per c.c.

Dilute sulphuric acid of maximum conductivity (battery acid) has a specific resistance of 6 ohms per c.c. The velocity of gaseous ions under unit electric force varies inversely as the gaseous pressure, at least approxinately. If p_0 is the density of the air at the earth's surface and p is the density at a height of h kilometres, then it is easy to show that

$$2.3026\,log_{10}\frac{p_0}{p}=\frac{gh}{RT10^5}$$

where g is the acceleration of gravity, T absolute temperature and R is the gas constant. Since $R=(83\times 10^6)/M$ where M is molecular weight we have approximately

$$log_{10}\frac{p_0}{p}=\frac{M}{2}\frac{h}{T}$$

Suppose, for simplicity, we take the atmosphere to have an average molecular weight of 20, and if we assume the average temperature to be 200° absolute, we find that at a height of 100 kilometres the density of the air would be about ten millionths of its density at the surface. The ionic

velocity under unit electric force might therefore be about

$$\frac{28}{10^9} \times 10^5 = \cdot 0028 \text{ cm/sec.}$$

If then there are 10^6 or 1 million ions per c.c. the specific resistance would be

$$\rho = \frac{10^{21}}{16} \frac{10^4}{28} \frac{1}{10^6} \frac{1}{10^9} \text{ ohms}$$

$$= 20 \text{ megohms, nearly.}$$

If there are only 10^5 ions per c.c. the resistivity would be about 2 megohms per c.c.

Bearing in mind that the upper regions of the earth's atmosphere above 100 kilometres level probably chiefly consist of hydrogen, and that the velocity of ions in hydrogen under unit electric force is, according to measurements, from 2 to 3 times that in oxygen or nitrogen at the same pressure, it is easily seen that in the upper hydrogen levels of the atmosphere a very moderate amount of ionisation, say, 10^7 ions per c.c., might give a conductivity of the order of that of fresh water, or about 700,000 ohms per centimetre cube.

(3.) Another quality this conducting layer must possess if it is to act as a true reflector of long waves is a somewhat sharply defined lower surface. When a ray passes from one medium to another true reflection will only take place if the change in conductivity or dielectric constant is very marked within the limits of a wave length or so. If the transition is gradual or irregular the regular reflection will not be found. If the periodic time of the wave is T, and if the conductivity is s, then the ratio of the intensity of the reflected ray to that of the incident is very nearly

$$1 - \frac{2}{\sqrt{sT}}.$$

This becomes unity if either conductivity or wave length are very large. Hence it is not sufficient to have an upper ionised layer in the atmosphere if it is to act as a guide to the waves. The conducting layer must have a somewhat sharply defined under surface.

23. It has already been remarked that observations on signal strength over long distances show an enormous difference between the actual measured values and those predicted by a simple diffraction formula.

A large number of observations have been taken at various times of signal strength or receiving aerial currents for distances up to 3,000 miles or so, and the results recorded in curves ([18]).

Attempts have then been made to find an empirical formula for the received current in terms of the other quantities involved.

At first these efforts started with the erroneous assumption that the attenuation might be regarded as due to an "absorption" caused by the atmosphere, and therefore mathematically represented by an exponential factor appended to the simple Hertzian expression for the magnetic or electric force at a known distance on the equatorial plane of a small oscillator.

A factor was subsequently added to correct for curvature of the earth and the empirical formula generally known as the Austin-Cohen formula is now given as follows:—

$$\frac{Ir}{Is} = \frac{377\, h_1 h_2}{\lambda\, d\, R} \sqrt{\left(\frac{\theta}{\operatorname{Sin} \theta}\right)}\, \varepsilon^{-0.0015\, d/\sqrt{\lambda}}$$

where h_1, h_2 are the effective heights of the transmitting and receiving aerials, d their distance and λ the wave length, all measured in kilometres, θ is the angular meridian distance of the stations and R the total resistance of the receiving circuit in ohms. The numbers 377 and 0.0015 ($=\alpha$) are empirical constants.

If in the exponent we put θ instead of d, then the exponential factor becomes

$$\varepsilon^{9.6\, \theta/\sqrt{\lambda}}.$$

This formula is stated to be valid up to a distance of about 2,000 miles, but to bring it into accord with observations several modifications of it have been suggested. However well it may fit in with observations taken over a limited range, it is nevertheless a purely empirical formula and cannot safely be extrapolated. If it is compared with the theoretical diffraction formula already given it will be seen that the chief difference is in the exponential factor which in the latter is $\varepsilon^{-23.9\, \theta\, \lambda^{-\frac{1}{3}}}$.

As this last expression was derived for the case of a spherical earth in free space, it appeared desirable to re-consider the diffraction problem, but assuming an enveloping spherical shell of semi-conducting material

(18) See L. W. Austin. Some Quantitative Experiments in long distance radiotelegraphy. Bulletin of *The Bureau of Standards*, Washington. Vol. 7 No 3, 1911. Also T. L. Hogan, Jr. *The Electrician*. August 8th, 1913. Vol. 71, p. 720.

surrounding the earth at a height of about 100 kms.

Professor G. N. Watson [19] accordingly took up this question and has given recently a solution of it. He finds that if in place of a perfectly conducting spherical earth in free space we assume an earth having a conductivity about the same as sea water, enclosed in a spherical sheath or shell of material having a conductivity of about 1.44×10^{-15} E.M.U., equal to a specific resistance of 700,000 ohms per c.c. or not far from that of ordinary fresh water, the interspace being about 100 kilometres, then the diffraction formula for the receiving aerial current would have to be modified and the exponential factor would become

$$\varepsilon^{-9.6\,\theta/\sqrt{\lambda}} \text{ in place of } \varepsilon^{-23.9\,\theta\,\lambda^{-\frac{1}{2}}}$$

and there would be agreement with the Austin-Cohen formula. Watson therefore considers that if we are able to assume an upper conducting layer in the atmosphere at a height of about 100 kms. having a fairly sharp under-surface and a specific resistance of about 700,000 ohms or, say, 0.75 megohm per c.c., then guided wave propagation through the included spherical shell of insulating air would account for the observed attenuation in actual terrestrial long-distance radiotelegraphy.

24. We have then to consider what are the probabilities and possibilities for the existence at a height of 100 kilometres or so of such a conducting layer and how it may be supposed to become ionised.

It may be remarked in passing that mere rarefaction in a gas does not of itself bestow electric conductivity. It is sometimes said that gases at a pressure of a millimetre, or perhaps less, are good conductors, as instanced by the ease with which an electrodeless discharge can be created in them by a high frequency alternating magnetic field.

Gaseous conductivity is, however, always and only due to the presence of ions, and in the above case these are created by the strong electromotive forces brought into play. In gases contained in glass vessels there are always some few free ions or electrons present for some reason. If a high frequency magnetic field is made to act on the gas these ions are driven with great force against the gas molecules and ionise them, thus producing very quickly a copious supply of ions and giving the gas high conductivity. We cannot, however, say that a rarefied gas is a good conductor *per se* for very feeble impressed electromotive forces as we can say that a metal is a good conductor. Hence mere rarefaction due to height will not bestow the required electric conductivity on the atmosphere. Neither can the required ionisation be produced by solar light, because then it would vanish in the night-time by re-combination of the ions.

25. The suggestion I wish to make as to the cause of this ionisation is based upon a modification of hypotheses already advanced by S. Arrhenius [20], K. Birkeland, and by W. J. Humphreys [21], concerning the projection of dust by light pressure from the sun.

We know that the sun's photosphere is in a continual state of disturbance due no doubt to violent explosions in regions beneath this light-giving locality. Above this photosphere lies the so-called reversing layer composed of metallic vapours which produce the Frauenhofer lines in the spectrum. These eruptions carry up not only metallic vapours, but also vast masses of the superlying chromosphere composed chiefly of hydrogen and helium gases in the form of solar prominences or red flames which are often seen rising to a height of several hundred thousand kilometres in a few minutes, thus indicating velocities of several hundred kilometres per second. When these solar metallic vapours are thus carried up into colder regions they must be condensed into a metallic mist or rain composed of particles of various sizes. We know also from experiment as well as theory that light exercises a pressure on solid objects and that this pressure per square cm. for totally absorbing or black bodies is numerically equal to the light energy in the cm. cube. Measurements made of the so-called solar constant at the earth's surface when corrected for atmospheric absorption give a value of 2.5 gram calories per sq. cm. per minute. Hence the energy of light per c.c. is nearly $6/10^5$ ergs and the light pressure therefore $6/10^5$ dynes per sq. cm. on a black surface. But at the sun's surface this pressure is 46,000 times greater, or 2.75 dynes per sq. cm. As this pressure

(19) G. N. Watson. *Proc. Roy. Soc., Lond.* Series A. Vol. 95, p. 546. 1919.

(20) Svante Arrhenius. *Worlds in the Making.* Harper Bros. 1908. English translation by Dr. H. Borns.

(20) Dr. W J. Humphreys. *Astrophysical Journal*, May, 1912.

varies as the square of the linear dimensions of the particle whilst gravitation varies as the cube, it is clear that as the dimensions of a particle decrease a limit will be reached at which the light pressure will overbalance the gravitation attraction.

It is easy to prove from known data that at or near the sun's surfaces black particles of the density of water would be just repelled if they had diameters of 15,000 Angström units $=150/10^6$ centimetre.

If their density is 5.5, then the critical diameter will be 2,700 A.U. If, however, the particles have diameters of only 1,600 A.U. and unit density the light pressure will be 19 times greater than the gravitation attraction. For sizes still smaller the light pressure would decrease again, and for diameters less than 500 A.U. gravity would once more preponderate. (See Fig. 5.)

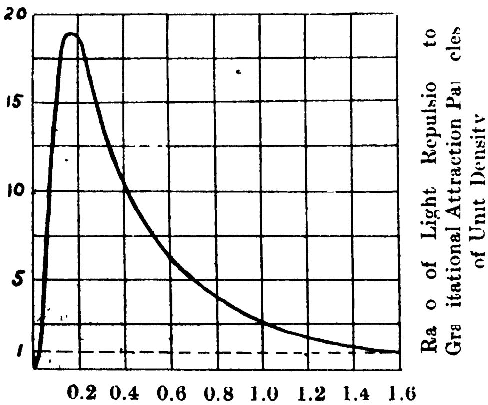

FIG. 5.—Curve showing the variation of the ratio of light pressure to gravitation for particles of unit density and various diameters.

If, then, the solar eruptions drive up into colder regions vapours which are condensed to liquid or solid particles, a sorting action will at once come into play. Particles above a certain diameter will be drawn back into the sun. Particles below a certain diameter will be repelled away with great force by light pressure, and particles of a certain critical diameter will remain suspended in space. The solar corona may perhaps be in part composed of solar dust of this critical diameter, as Arrhenius has suggested. Now, as regards that dust which is repelled by the sun, it is easy to calculate the time particles of certain sizes will take to travel to the earth's orbit and the velocities they will then possess. Taking the particles to have unit density and three sizes, viz., 1,600 A.U., 5,000 A.U., and 10,000 A.U., and to be projected from the sun with velocities of 200 kilometres per second, I find that the times required to travel to the earth's orbit will be respectively 22 hours, 42 hours, and 76 hours.

The velocities with which they will arrive will be 1,700 kilometres per sec., 780 kms. per sec., and 350 kms. per sec. respectively.

26. These minute particles, composed, it may be, of carbon from the photosphere or metallic dust from the reversing layer or volcanic ash or other solar materials will in general carry electric charges. The high temperature will cause emission of electrons from the metallic particles, as also will the fierce ultra violet radiation to which they are exposed. The metallic vapours will also be in a state of ionisation, and the free electrons emitted will condense round them gases or vapours from the chromosphere as they pass through it. Hence the particles which are repelled by light may be either positively or negatively electrified or neutral. Owing to the greater tendency of negative electrons to condense vapours and attach themselves to groups of molecules, the negatively charged particles may be less dense and smaller than those positively charged. It should be noted, however, that isolated molecules or electrons are far too small in diameter to be repelled by light. It is only groups of molecules of at least 500 A.U. in diameter which can be repelled. Hence these dust particles will travel outwards from the sun with very different velocities. Some will come with great velocity and others with small speed.

In short, we may say that the sun, like a good housemaid, dislikes dust, especially dust of a certain degree of fineness, and pushes it away from it with great force. The moment that this electrified dust enters the earth's magnetic field with high velocity, forces will be brought to bear on it tending to separate the negatively and the positively charged particles. If H is the magnetic force of the earth and v the particle's velocity, and e its charge, then the separating force is Hev where H is that component of magnetic force at right angles to the direction of v and the separating force is also at right angles to the plane of H and v.

27. Another cause operating to effect a separation of the positively and negatively charged dust is found in the viscosity of the atmosphere. Roughly speaking, the viscosity of a gas is that quality of it in virtue of which fine particles experience a resistance in moving through it. Maxwell (22) showed long ago that the viscosity of a gas is independent of the pressure over wide limits. Crookes continued these researches and demonstrated that between atmospheric pressure and a pressure of about one ten-thousandth of an atmosphere the viscosity remains constant, but that when the pressure falls below this last figure the viscosity very rapidly decreases to zero. Again, both Maxwell and Crookes found that the viscosity of hydrogen is about half that of oxygen or nitrogen. (See Fig. 6.)

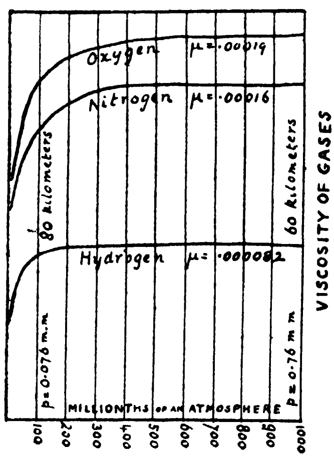

FIG. 6 —Variation of Viscosity with pressure for various gases (Crookes).

The viscosity of air at 760 mm. is 0.00018 C.G.S. units.

Sir George Stokes proved that if a small sphere of diameter d and density σ is falling through a gas of density ρ and viscosity μ under the action of gravity it will attain a final velocity v such that

$$v = \frac{1}{18} \frac{d^2 g}{\mu} (\sigma - \rho)$$

where g is the acceleration of gravity. This explains the extremely slow rate of fall of water particles constituting clouds, and also the very slow settlement of fine dust particles through air.

The positively charged solar dust particles are probably larger than the negatively charged particles, as the latter consist of electrons having condensed round them molecules of gases, probably hydrogen and helium, gathered from the solar chromosphere. Accordingly the negative ions will be brought to rest before the positively charged particles and gas viscosity will assist the separation. Stokes showed that a small particle of diameter d moving with a velocity v through a gas of viscosity μ is losing kinetic energy at a rate $3\pi d \mu v^2$. Hence, if m is the mass of the particle,

$$mv \frac{dv}{dt} = - 3\pi d \mu v^2$$

The solution of this equation is

$$v = V_0 \varepsilon^{-3\pi d \mu t/m}$$

where V_0 is the initial velocity. If we consider that the particle is practically at rest when $v = 1$ cm. per second, then we have for the time t in which its velocity is reduced from V_0 to 1 cm. per second the equation,

$$t = \frac{m}{3\pi d \mu} \log_e V_0 = \frac{d^2 \rho}{6 \mu} \log_e V_0$$

where ρ is the density of the particle.

The above equations, however, are only true approximately Stokes' expressions apply to smooth spheres and not to irregularly shaped particles. Also, if the diameter of the particle is much less than the mean free path of a gas molecule, the expression for the frictional resistance is not $3\pi d \mu v$ but this quantity divided by $1 + 2\alpha L/d$ where L is the mean free path of a gas molecule and α is a constant depending on the nature of the particle and its form.

If, then, particles of dust enter the highly rarefied upper hydrogen levels of the atmosphere, they will experience very little retardation until they reach that level (about 100 kms. high) at which viscosity begins to increase rapidly to its normal or full value, but then they will be very quickly brought to rest even in spite of their high initial velocity.

Hence none of this dust will penetrate below a certain level in the atmosphere, probably about 60 to 80 kms. high. It will be stopped and held by air viscosity. The moment its velocity falls off the forces tending to separate the oppositely electrified particles will also decrease, and the oppositely charged particles may then neutralize each other. The result will be, as I think, to

(22) See J. Clark Maxwell. *Phil. Trans. Roy. Soc., Lond.* Vol. 156, p 249. 1866

Also W. Crookes. *Phil. Trans. Roy. Soc., Lond.* 1881. Part II., p. 387. Plate 57. On the Viscosity of gases.

give the highly conductive layer in the earth's atmosphere a tolerably well-defined under-surface determined by the very rapid rate at which air viscosity rises with increasing air pressure. Hence it is clear that when the dust particles reach a certain level their earthward progress will be practically arrested.

Meanwhile the region above this will be left impregnated with the smaller and lighter negative ions which are moving slowly or quickly in directions oblique to the earth's magnetic meridians and winding their way spiral-fashion towards the regions of the magnetic poles. The explanation of numerous astronomical, meteorological, magnetic and atmospheric electric phenomena by the aid of this hypothesis of electrified solar dust projected by light pressure from the sun to the earth has been worked out in great detail by S. Arrhenius, K. Birkeland (23), W. J. Humphreys and others, but time will not permit of any recapitulation of their published conclusions. This solar dust hypothesis seems to be supported by the observations of Newcomb, Yntema, Abbott and W. W. Campbell on the fact that on clear moonless nights the sky sends to us more light than can be accounted for by the sum total of starlight, and that this extra light is notably greater near the horizon than at the zenith, also by the spectroscopic observations which show the green auroral line in all parts of the tropical sky on moonless nights.

28. In addition to this hypothesis of a permanently conducting upper region of the atmosphere we are compelled to postulate that beneath this there must be a region of variable ionisation due to solar light, which is ionised during the day above the level of clouds dust and water-vapour, but more or less dis-ionised during the night.

Dr. Eccles (24) has worked out the consequences of assuming an atmospheric region in which ions of molecular mass are present, possibly formed by the action of ultra violet light on molecular groups which are photo-electric. The presence of these heavy ions acts to produce what is in effect a reduction in the dielectric co-efficient and therefore an increase in the velocity of electric waves through the ionised region.

This action may be illustrated by a magnetic parallel. If iron spheres were placed in a magnetic field they would be magnetised, but owing to the reverse action of the free poles the magnetic force in the iron would be less than the force at that point if the iron were not there. Hence the magnetisation produced is not that which corresponds to the external impressed magnetic force, but to the reduced magnetic force.

In the same manner if heavy ions are present in the air the orderly arrangement of them by the impressed field reduces the effective electric force in the space occupied by them, and this is equivalent to a reduction in mean dielectric constant. But the velocity of the wave is inversely as the square root of the dielectric constant, and therefore the wave speed is increased. From this it follows that if there is a gradually increasing density of heavy ions of both signs as we rise higher in the atmosphere, there will throughout that region be a gradually increasing electric wave velocity with height, and therefore an effect which has been called *ionic refraction* in virtue of which the higher levels of a plane electromagnetic wave advancing over the earth will advance more quickly than the lower parts. Hence the wave track will follow round the earth's curvature and an obliquely rising ray may even be brought down again to earth by an action resembling that of an inverted mirage.

The very complicated phenomena connected with freak signalling, the great effect on signal strength of the sunset and sunrise periods, the curious anomalies in the difference between daylight and night-time radio transmission for various wave length and variation in range between north-south and east-west transmission, have all received certain plausible explanations on the theory of a variable ionisation by sunlight of the atmosphere, and its irregularities at the bounding surface of the earth shadow cone as it sweeps through the atmosphere. The atmospheric ionisation at this surface will tend to become "patchy," and will therefore bestow a certain increased opacity and increased reflecting power on that region for electric waves just as small air bubbles in water give it a certain opacity for visible light.

The general increase in range of radio communication by night is accounted for on this theory as due to partial removal

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(23) See *Recent Physical Research*, by David Owen (Benn Bros. Bouverie Street, London).

(24) W. H. Eccles. *Proc. Roy. Soc., Lond.* A Series. Vol. 87, p. 81. 1912. Also *The Electrician* September 27th, 1912.

of the ionic refraction which in the daytime brings the ray down again to earth at ranges less than that due to the guiding properties of the permanently ionised higher layer.

On the other hand, there are curious exceptions to this in the case of certain long-wave transmission. Marconi [25] long ago pointed out that with certain wave lengths from 5,000 to 6,000 metres transatlantic radio signals are often stronger by day than by night. These anomalies and others recorded by Dr. Eccles [26] seem, however, to meet with reasonable explanations on the ionic refraction theory.

On the other hand, our difficulties are great in bringing these hypotheses to critical test. The atmospheric region in which the phenomena takes place is far beyond the reach of our meteorological sounding balloons or possibilities of testing the actual ionic distribution. We can only, therefore, patiently continue to collect the facts and trust to cautious inductive reasoning and observations to give us the true interpretation of them. All the phenomena seem, however, to point to the existence of three superimposed layers in the atmosphere: one, the higher beginning perhaps above 80-100 kilometres' height, which is permanently ionised with negative ions.

The other, the middle, which has in part variable ionisation depending on the position of that part with regard to the sun.

The third or lower level has a relatively small ionisation, but electromagnetic waves travelling in it may have their energy considerably affected and reduced by the nature of the earth's surface over which they are moving. Powerful absorption is caused by some soils and by vegetation for certain wave lengths.

IX. Radiotelegraphic Disturbances by Natural Waves.

29. From the earliest days of long-distance wireless telegraphy the difficulties in reception due to vagrant or natural electric waves and atmospheric electric discharges passing down the receiving aerial have been the bane of the wireless telegraphist. These waves create sounds in the telephone in aural reception which often drown out completely the signal sounds and make false records in the case of printing or photographic reception. In the case of telephone reception, these noises have been classified into (i) rattling or grinding, (ii) hissing, (iii) clicking or snapping, and (iv) crashing noises. These two last seem to be associated with thunderstorm conditions. Having regard to the fact that the positive atmospheric electric potential gradient of the earth increases at the rate of about 100 volts per metre of ascent, roughly speaking, it is not surprising that aerials several hundred feet high may be traversed by quite large currents due to this cause alone which may utterly swamp the feeble signal currents. The strength of a signal or noise in the telephone is generally estimated by its "audibility," and this is measured by ascertaining the resistance S of the shunt which must be put across the telephone of resistance R just to render the sound inaudible to a normal ear. The audibility A is given by the expression,

$$A = \frac{R + S}{S}$$

Hence the audibility is unity for a just audible sound. We can in this way measure the audibility of a signal on a background of disturbing noise, and a readable signal is generally obtained if the ratio of signal audibility to stray audibility is more than 25%. Owing to the serious extent to which these strays hinder regular reception, especially at certain times of the day and year, an enormous amount of attention has been given to their study and to the problem of eliminating them. They are most troublesome in the summer and during the night, and more severe in tropical than in temperate climes. Even in our latitudes they hinder reception at times immensely. Dr. L. W. Austin has stated that receiving at Washington, U.S.A., with a simple loop aerial from high power radio stations in Europe with aerial sending currents up to 300 amperes, signals were unreadable for about 2,000 hours a year. In tropical countries over long-distance circuits the power required to get a signal through may be often from 6 to 8 times that which must be used at favourable times, and there are short periods when signalling is absolutely impossible. Having regard to the effect such interruptions have upon the earning power of a commercial station or upon certainty of communication in time of war or other urgent occasions, the problem of elimination of strays is perhaps the most important of all the practical questions connected with long-distance wireless tele-

(25) G. Marconi. Friday Evening Discourse at the Royal Institution, London. June 2nd, 1911.

(26) W. H. Eccles. On certain Phenomena accompanying the Propagation of Electric waves over the surface of the Globe. *The Electrician.* September, 1912.

graphy. It has been the subject of countless patents already. Early attempts went on the supposition that the strays were highly damped vagrant waves or had particular frequencies and could be eliminated by giving the receiving system a very pronounced resonance and making it a so-called stiffly-tuned circuit. These methods had a very limited application, for the reason that any impulse given to the receiving aerial sets it in electric vibration with its own natural period. Then, again, a number of inventions depend upon the peculiar properties of certain detectors, such as crystals and thermionic valves, in limiting the current which they pass or rectify. One most practically useful discovery was that by giving to the spark or wave train in the case of spark systems or to the beats in the case of C.W. heterodyne reception a regular frequency of 500 or 600, thus imparting a rather shrill musical sound to the signal, the ear could much more readily fasten attention on it even against a background of irregular but louder noise due to atmospherics.

Another interesting discovery was that of the subterranean or submerged horizontal collecting wire. If a pair of equally long wires are submerged a foot or two under water or buried in damp soil, with a suitable detector at the junction, it can receive from distant stations lying in its own direction, provided we use a two-stage thermionic amplifier in the centre. The optimum length of the wire is about equal to the wave length, but depends to some extent upon the capacity per unit length of the wire used. Such a buried or submerged aerial is largely immune from stray disturbance. The remarkable thing is that reception is far better when the wire is laid in water or wet soil than on the surface of the dry ground. Although the signals received on a buried wire are much weaker than on an aerial wire or vertical loop, the former has the great advantage of directivity and stray elimination.

30. By the combination of a frame or loop aerial with a ground or water wire it is possible to construct a receiving system which is somewhat superior to an ordinary aerial wire in its immunity from stray disturbances (27). Another method, claimed by Mr. Roy A. Weagant (28), of the Radio Corporation of America, but really due, I think, to Mr. Franklin, of the British Marconi Company, depends upon the use of two loop aerials with planes vertical and in line with the sending station. These two loops are tuned with capacities and inductances for the wave length to be received and connected in opposition through a coupling circuit with the receiving circuit. The difference in phase of the received currents in these two loops creates the signal, and it has been claimed that by this double loop aerial the stray disturbance is greatly reduced. Mr. Weagant explains this action by the hypothesis that the "grinders" type of stray most prevalent in warm seasons and in the afternoon and evening come down vertically from above. Dr. L. W. Austin disagrees with this view, but there are some reasons supporting Weagant's opinion.(29) Austin has recently tested four methods of stray elimination at the United States Naval Radio Research Laboratory, U.S.A., viz.:—

(1) The Weagant double loop system used at Lakewood, New Jersey, U.S.A.
(2) The Hoyt-Taylor loop and grounded wire system at Belmar, New Jersey, U.S.A.
(3) The U.S.A. Naval Research Laboratory system used at Anacostia River, Washington.
(4) The Otter Cliffs system used at the Naval Station, Maine, U.S.A.

Dr. Austin has stated that with any of these four systems the time during which signals from high power radio stations in Europe are unreadable at Washington, U.S.A., was reduced from 2,000 hours per year to less than 100.

Without some such stray elimination the period of time during the summer months in which these European stations were readable at Washington, U.S.A., was for more than 6 or 7 hours out of the 24. It is probable, however, that rather too favourable an opinion has been given of these devices.

In an interesting paper on the nature and elimination of strays by Dr. C. J. de Groot (30) in 1917, he mentions the use of

(27) A. Hoyt Taylor. *Proc. Inst. Radio. Eng., Lond.* U.S.A. Vol. 7, p. 337. August, 1919. Short-wave Reception and Transmission on ground wires. Subterranean and Submarine.

(28) R. A. Weagant. *Proc. Inst. Radio. Eng.* U.S.A. Vol. 7, p. 207. June, 1919.

(29) L. W. Austin. *Proc. Inst. Radio. Eng.* U.S.A. Vol. 9, p. 41. February, 1921. The Reduction of Atmospheric Disturbances in Radio Reception.

(30) C. J. de Groot. *Proc. Inst. Radio. Eng.* U.S.A. Vol. 5., p. 75. April, 1917.

another method of stray elimination devised by M. Dieckmann, which consists in surrounding the vertical aerial with a sort of cage formed of horizontal wires, these wires being earthed in a particular manner so that the cage is out of tune with the aerial. It is claimed that this cage shields the aerial from all those electrostatic disturbances which are caused by electrified clouds or normal atmospheric potential variations, but allows the aerial to receive the signal waves of which the electric vector is perpendicular to the shielding wires.

de Groot states that this Dieckmann cage is effective in tropical climates in cutting out hissing and rattling telephone noises due to certain strays, but did not exclude clicks due to lightning discharges.

31. Dr. de Groot made an immense number of observations on stray strengths at various hours of the day and months of the year about 1916 in the Dutch East Indies, and prepared diagrams showing the mean stray strength for various hours for each month of the year. From these he prepared a diagram giving the hourly stray strength during the day averaged throughout a year. The results were plotted as a rectangular co-ordinate curve with stray strength shown by the height of an ordinate whose abscissa was the hour of the day by sun or local time. The most interesting result, however, was obtained when this

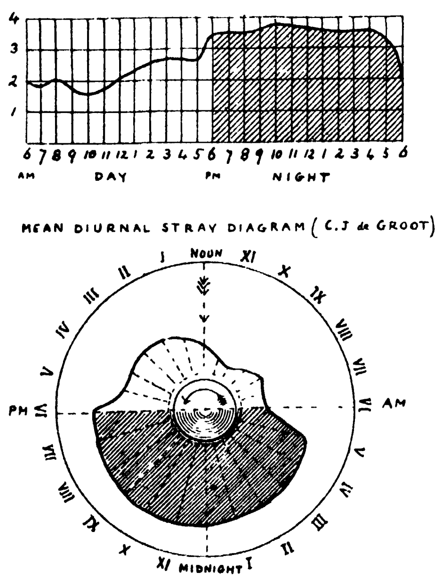

FIG. 7.—Diagrams showing the mean diurnal variation of stray intensity. (C. J. de Groot.)

average stray strength was plotted as a polar diagram for each hour, the radio vectors being 15° apart. (See Fig. 7.)

If we suppose ourselves to look down on the earth from above the North Pole, then a vertical aerial at the Equator would revolve counterclockwise and the Polar diagram of stray strength, if plotted round the diagram, would be a closed curve which has a minimum radius at about 10 a.m. or so and a maximum radius at about 10 p.m. The radii of the curve during the day are smaller than that during the night.

The diagram then suggests at once the question: Why are the strays in general more numerous and stronger during the night than the day?

We have seen that there must be a certain intermediate but high level region in the atmosphere in which the gases are ionised by the ultra violet sunlight during the day, but re-combine again during the night. This region lies beneath the permanently ionised layer. In this permanently ionised layer there are drifting collections or masses of positively electrified and negatively electrified solar dust. If these masses are drawn together by their electric attractions or commingled, it is highly probable that electric re-combinations will occur, which would generate electric waves. Suppose, then, that we assume the origin of a certain part of the strays to be in the upper permanently conductive layer of the atmosphere, these natural waves would find a certain obstacle to their downward transmission in the conductivity produced by the ionisation of the middle layer of the atmosphere by day. But at night-time this middle layer ionisation largely disappears and the natural electric disturbances in the upper layer would more easily find their way down to the earth. In other words, there would be a more unhindered access for the strays to descend. Hence in the night-time they would be more numerous and apparent in the effect they produce on receiving appliances.

The view that the strays which produce continuous rattling or grinding noises in the telephone have their origin in the high level permanently conductive layer of the atmosphere was also put forward by Dr. de Groot, and he has employed ingenious arguments to obtain an estimate of the height of this layer, which he places at between 180 and 200 kilometres.

These estimates must, however, be brought into comparison with the observations which have been made on the heights of the Aurora. Störmer has made precise measurements of the parallax of the beams and arches of auroræ by photographic observations at places connected by telephone, and found, out of 150 observations, that the lowest occurred at 40 kms. and the highest at 260 kms. Much, however, depends upon latitude and the height of the region ionised by cosmic dust may be greater at the terrestrial equator than at the poles. The whole subject is of great importance in connection with meteorology and terrestrial magnetism, and invites the co-operation of physicists, astronomers and meteorologists, as well as radio-engineers.

The matter is, however, of such immense practical importance in radiotelegraphy, that improvements or inventions connected with it are generally kept as carefully-guarded secrets, at least, for some time. Senator Marconi spoke recently of inventions due to himself and technical staff which promise a great advance in overcoming the interruptions of service due to strays, but details are at present withheld.

Time does not permit any more extended reference to the work of Marconi, Round and Tremellen, Franklin, Eccles, Austin, Hoyt-Taylor, de Groot, Fessenden, Weagant, and many others who have devoted great attention to this extremely important matter during the last two decades.

The problem of eliminating altogether the effect of strays on the receiver is at present the paramount one in long-distance wireless telegraphy, as they are then a source of far greater difficulty than in short-distance working.

X. Is there an Æther ?

32. In bringing to a conclusion this brief and imperfect sketch of the progress in 21 years of long-distance radiotelegraphy, it is impossible not to give a moment's attention to a question which is fundamental in connection with it. The starting-point for all this work was that great product of James Clerk Maxwell's incomparable genius, the electromagnetic theory of light. It postulated a universal medium, identified with the luminiferous æther of Fresnel and Young, in which the effects we call magnetic flux and electric strain are propagated as a wave motion. It was in the attempt to verify certain deductions from Maxwell's theory that Hertz was led to give us the experimental means of producing Maxwell's waves. The researches of some of the world's most notable scientific investigations provided the basic facts on which equally distinguished inventors have built up the splendid edifice of modern radiotelegraphy. But of late years facts have been discovered which seem irreconcilable with the original form of Maxwell's theory and with the previously held view that radiant energy is uniformly spread over its wave front and emitted continuously by a radiating body. Observations on the energy aspects of ionisation by light, the distribution of energy in the spectrum and of specific heats, seem to suggest that the energy of a light wave is concentrated along certain lines or points on the wave front surface and emitted and absorbed in certain finite units called quanta. Moreover, no experiments yet devised have enabled us to determine any motion of this hypothetical æther relatively to the earth or any other moving matter. If the electromagnetic medium exists as a stagnant æther in space, and if the earth moves through it like an aeroplane through the air, then what may be called an æther wind is blowing through our laboratories with a velocity in some directions and at some times of at least 30 kms. per second. The classical Michelson and Morley experiment was designed to detect this æther movement if possible by its effect on the time taken for light to move a certain distance there and back along and across this æther wind. But, to the surprise of physicists, the result showed an absolute equality in these times, quite different from the result which would have been found if we had employed waves of sound in moving air. Other experiments by Lodge, Trouton, Rayleigh and Brace gave similar null results.

Certain mathematical physicists have therefore declared, as Professor Eddington did lately at Edinburgh, that "the æther "must now be regarded as an idle hypothesis "unsupported by experiment and giving "explanations of nothing."

Others, on the other hand, consider that the facts of physics do not justify this conclusion.

We know that light not merely takes time to travel and brings intelligence of distant events, but conveys energy in enormous quantities from place to place. A cubic mile of space filled with sunlight

near the sun's surface contains at least 300,000 foot-tons of energy, enough to hurl 20 tons over the top of Mont Blanc.

Energy comes in vast amounts from the sun to the earth and occupies $8\frac{1}{4}$ minutes in the journey. We then ask: How, and in what manner, is that energy stored up and conveyed *after* it has left the sun and *before* it reaches the earth? Again, a light exerts a pressure upon objects on which it falls. The sun, by its radiation, presses the earth and other bodies away from it, and the reaction presses the sun back. In what, and where, does this stress exist?

Radio-engineers who regard in all cases the energy aspects of a problem may be content to take the guidance of mathematicians on the relativity of our ideas of space, time, velocity, acceleration and the other concepts of kinematics and geometry, but they will hardly be willing to surrender the opinion that space is not mere emptiness or a *vacuum*, but is a *plenum* possessed of very definite powers of energy storage and energy transmission. It is clear, however, that some great enlargement of our views about the electromagnetic medium is necessary to make them embrace new knowledge. The æther may be elusive, as elusive as the Scarlet Pimpernel in Baroness Orczy's famous story, but it is the aim and duty of physics to find the generalizations which will harmonize observed facts and explain them all by one consistent theory. Some of these difficulties can be minimised if we return to Faraday's idea that light, and therefore electromagnetic waves, are vibrations propagated along lines of electric force. This conception has been mathematically developed at great length by Sir Joseph Thomson and expounded by Dr. Norman Campbell. Since lines of electric force proceed from electrons, positive and negative, and on the Faraday-Maxwell theory have tension (T) and mass (M) per unit of length, the velocity of propagation along them is $c = T^{\frac{1}{2}}M^{-\frac{1}{2}} = 3 \times 10^8$ metres per second. The electron may therefore be regarded as the centre of a radiating system of lines, I call *electrolines* for shortness, along which vibrations are propagated when the electron vibrates.

In this sense, then, every source of radiation makes its own æther. If a vibration proceeds from a source and is reflected back by a mirror, the vibrations run out along the electrolines proceeding from the electrons in the source and return along electrolines proceeding from electrons in the mirror. If, then, a source and a mirror are rigidly connected together, the time taken by a vibration to run from the source to the mirror and back again, as in the Michelson-Morley experiment, will be quite independent of the manner in which the system is being moved about.

From this point of view, all space is filled with interlacing electrolines and has a fibrous structure. But even if such an hypothesis may explain some facts, it probably raises more difficulties than it meets. We await some second Newton or Maxwell whose genius will dissipate the clouds that still shroud in darkness the structure of space and the nature of radiant energy.

Meanwhile the radio-engineer deals with phenomena which lie on the borderland of our finite knowledge and our infinite ignorance. In 21 years he has been able so to control the subtil energies of Nature that he has made of the world one vast auditorium in which long-range radio stations now speak simultaneously to every place on the habitable earth at which a suitable receiver is placed.

Our hope and desire is that these enlarged powers of communication may be exercised for the benefit of humanity at large and promote peace and goodwill between all the nations which make up the family of mankind.

DISCUSSION.

THE CHAIRMAN (Mr. Alan A Campbell Swinton, F.R.S.), in proposing a hearty vote of thanks to Professor Fleming, said the lecture that had just been delivered was one of the most interesting and memorable lectures that had ever been given in the Hall of the Society. Professor Fleming had devoted his life to electrical matters, and during the latter half of his life he had dealt particularly with those electrical matters that appertained to wireless telegraphy. He thought Professor Fleming was the greatest publicist in the world in the way of writing books on the subject, and in the present year the Royal Society of Arts conferred upon him the highest honour it was able to award, i e., the Albert Medal, for his invention of the thermionic valve, which had done so much to promote the extension of wireless telegraphy. It was now 21 years since long distance wireless telegraphy had been invented, and Professor Fleming had given a most interesting account of its coming of age. The Society and the meeting were honoured by the

presence of the one individual who had done more than anyone else to produce the wonderful results referred to in the lecture. He alluded, of course, to Senatore Marconi, who, like Professor Fleming, had received the Society's Albert Medal, and he would ask him to second the vote of thanks to Professor Fleming.

SENATORE G MARCONI, G.C.V.O., LL.D., D.Sc., said it gave him great pleasure to second the vote of thanks to Professor Fleming for his extremely interesting lecture, which he had very appropriately entitled "The Coming of Age of Long Distance Radiotelegraphy" Those present that evening had had the pleasure of listening not only to Professor Fleming's clear and scientific exposition of the progress and development of long distance radiotelegraphy, but also to the brilliant views which he had put forward to account for some of the still unexplained facts of wireless telegraphy Personally he was particularly interested in the hypothesis that the apparent bending of electromagnetic waves round the curvature of the earth might be due to their reflection from a more or less sharply defined upper layer of the atmosphere—containing highly ionised dust flung off by light pressure from the sun. Not only was that matter of practical and scientific interest for transmissions over what he might now call moderate distances, i e, distances of a quarter of the way round the world, but it possessed a still greater interest with regard to the problem of communicating with places close to the Antipodes. The relative facility with which signals were now transmitted from England to Australia seemed to prove that there was something in the idea of the waves bending round and concentrating at places near the Antipodes Sixteen years ago he expressed that view in a lecture which he delivered before the Royal Institution, when he showed a model of the globe and tried to explain how he thought the waves might help each other if in proper phase, or, in other words, concentrating at places at the Antipodes or the transmitting station. If that was true, it might be a fact that messages could be sent to the Antipodes with a very much smaller amount of energy than was necessary to send them to places at shorter distances Not only was wireless telegraphy indebted to Professor Fleming for his numerous and valuable contributions to the theoretical side of the subject, but personally he wished to put on record once more Professor Fleming's most valuable co-operation in the early design of long distance transmission plants at Poldhu and other stations, and, with regard to the practical side of radiotelegraphy in general, much gratitude was due to Professor Fleming for his invention of the Fleming thermionic valve, which was perhaps one of the most important contributions to the practice of long distance communication. The improvements made to that arrangement not only constituted it the most practical and the most sensitive receiver, but also enabled it to be used for the transmission of messages as an oscillation producer which, in his opinion, was the most practical and efficient now in existence He need not say how fascinating the possibilities of long distance radiotelegraphy were and how every day they became still more fascinating He was still busily engaged in working on the subject, which had also attracted the attention of a great many other people all over the world. In that connection he might say that his contact with so many phases of radiotelegraphy had lately given him the impression that, so far as the practical side of long distance communication was concerned, those who were working on the subject had perhaps rather got into a rut If there was found to be no ether, the views at present held might have to be changed, but he hoped that whatever was ascertained would go to improve the fascinating application of science with which the lecture had dealt He was very happy to second a warm vote of thanks to Professor Fleming for his extremely interesting and brilliant Lecture, a vote of thanks which had been so ably proposed by the Chairman, and he wished to assure Professor Fleming how deeply everyone present had appreciated the privilege of listening to the lecture

The resolution was carried unanimously.

PROF J. A FLEMING, M A, D Sc, F R S., in reply, said he was particularly grateful to the Chairman for his remarks and also to Senatore Marconi for honouring the meeting by his presence and for honouring him personally by seconding the vote of thanks.

The meeting then terminated.

NOTES ON BOOKS.

RECOLLECTIONS. By Sir Charles W Macara, Bart. London, New York, Toronto and Melbourne: Cassell & Co, Ltd 7s 6d. net.

A friend, herself a daughter of the manse, once confided to the writer of this note, that it was her ambition to write a book called "Sons of the Manse," in which she hoped to demonstrate how much the British Empire and the world at large owed to this admirable race. If the book is ever written, the name of Sir Charles Macara ought to hold an honoured place in it. Born in the manse of Strathmiglo, Fifeshire, in 1845, with nothing but his own energies to depend upon, Macara, at an early age, reached a responsible position in connexion with the representation in Manchester of one of the super-firms in Scotland, and he soon came to be regarded as the head of the cotton industry, which, after agriculture, is the most important industry of Great Britain.

In the work before us, Sir Charles looks back from the comparative leisure of retirement, over the principal events of an extraordinarily useful and busy life, and he selects a few of the most interesting for review. If he had nothing to his credit beyond his share in carrying through the Brooklands Agreement of 1893, Sir Charles would have deserved well of his country Not only did this Agreement endeavour to substitute in the cotton industry a reign of reason for a reign of force, and to tie both employers and employed to rules which would make it as difficult as possible to enter upon either a lock-out or a strike; it did a great deal more than that: it dealt with the question of the workers' right to a "say" in industry—a question that was not settled by the railways till twenty years later

Sir Charles's account of the battle over the Brooklands Agreement is of extraordinary interest The representatives of the two sides, employers and employed, met at Brooklands, a suburb about seven miles from the centre of Manchester. The conference began at three o'clock on March 23rd, 1893. Six times during its course, the two sides broke away from each other Happily there was one man on each side determined to bring the matter to a satisfactory issue—Sir Charles Macara, representing the employers, and James Mawdsley, leader of the employees Thanks to the efforts of these two, agreement was at last reached at five o'clock in the morning of March 24th; and as a result, for the next twenty one years there was only one strike regarding wages that affected the whole industry, although before this time, the cotton trade was known as the cock-pit of industrial strife

Another feather in Sir Charles's cap was the establishment of the International Cotton Federation He was its President from its formation, at Zurich in 1904, until the year 1915. It would be impossible to over-estimate the value of the work which the Federation has done in drawing together the cotton-using countries of the world Annual conferences were held in Germany, Austria, France, Italy, Belgium, Spain, Portugal and Holland, and international delegates visited America and Egypt "The movement," writes Sir Charles, "was prosecuted with great vigour until the war interfered with its operations, and perfect harmony characterised its deliberations"

A further international movement which owed not a little to the services of Sir Charles was the establishment of the International Institute of Agriculture. He was among the first to realise the greatness and importance of the scheme proposed by David Lubin, and he threw himself whole heartedly into the task of realising Lubin's idea The International Institute of Agriculture is now a *fait accompli*, and the bulletins which it issues are regarded as of first rate value wherever scientific agriculture is practised. "Since their formation, in 1904 and 1905, respectively," to quote Sir Charles again, "these two international movements have been in continual co-operation . . .. and have demonstrated that work for the benefit of mankind may be done and will be done quite readily by men drawn from numerous countries, who, in the doing of it, willingly sink their distinctions of nationality"

Want of space prevents our referring at any length to Sir Charles's magnificent work in the war and in the coal crisis of this year, but a word must be said of his work for the National Lifeboat Institution In 1891 he issued an appeal on its behalf, and he started the eminently successful movement known as "Lifeboat Saturday" Mainly as a result of his labours (which were merely a *parergon*, an addition to his ordinary day's work), the income of the Institution was raised from £42,000 in 1891, to £137,000 in 1919

The life of Sir Charles Macara, with its generous, unselfish and finely practical aims, should serve as an inspiration to the young business man

OBITUARY.

The Earl of Halsbury.—The veteran lawyer and statesman, Lord Halsbury, died in London, on December 11th, at the great age of ninety-eight Coming of an ancient Norman line, he was the son of Dr. Stanley Lees Giffard, a contributor to the *Quarterly Review*, and for a very long time Editor of the *Standard*, in whom it was said departed the last of the school of Georgian political writers who brought so great a fund of learning to the press.

Lord Halsbury was not only the longest lived of English Lord Chancellors, but he held the Great Seal for about seventeen years, a term exceeded by only two of his predecessors Hardwicke and Eldon.

Educated at Merton College, he was called to the Bar in 1850, and soon achieved a reputation as an advocate in criminal cases, though, unlike some of his brilliant contemporaries at the Old Bailey, he also engaged in civil work. He took silk in 1868 and about this time distinguished himself by his powerful defence of Ex-Governor Eyre. In 1875, in spite of his not then being a member of the House of Commons, he was appointed Solicitor-General. He did not succeed in obtaining a seat in Parliament until 1877, when he was elected for Launceston, and at last was able to join his colleagues on the Treasury Bench. He continued to represent Launceston until 1885, when he became Lord Chancellor in Lord Salisbury's first Administration. He filled the same office in four Governments. It has been said that his name will always be connected

with one of the greatest reforms, that enabling prisoners to enter the witness-box and give evidence. In his later years he devised and supervised the issue of "The Laws of England" He was President of the Royal Society of Literature, Senior Grand Warden of English Freemasonry and High Steward of Oxford University. He was a Life Fellow of the Royal Society of Arts, having been elected as long ago as 1866. He served on the Society's Council as a Vice-President from 1894 to 1898.

THE RUBBER INDUSTRY OF BOLIVIA

The rubber industry, one of the most important in Bolivia, is centred in the Amazonian region of the Republic Though the first rubber was taken out along the Mamore in 1864 and production amounted to 2,000 arrobas (of 25 36 pounds each) by 1878, the development of the industry on a large scale dates from the eighties Much of the rubber country was explored about that time by an American The year 1882 was a great one in the history of the industry, but the depression caused by the outbreak of swamp fever, which followed the floods of 1886, caused a temporary setback With the rapidly increasing demand for the product, rubber hunters poured into the Beni and Mamore districts, and numerous companies were organized to exploit the resources of those regions. The production of 1898 was double that of the previous year and in 1900 reached the highest figure attained until 1911. However, the best returns from the business were during the boom years from 1909 to 1911, during which period rubber reached the maximum price of 12 shillings per pound From that time the decline in the returns was constant until 1915, but the yield of 1917 brought only about two-thirds as much as did that of 1910 By 1917 the East Indian plantations were producing and Amazonian rubber had taken the second place in the world market, at least in so far as quantity was concerned.

According to a report on the industry by the United States Trade Commissioner in Bolivia, rubber is found in the Territory of Colonias and in the four northernmost Departments of the Republic—El Beni, La Paz, Cochabamba, and Santa Cruz. The Beni district has steadily declined in relative importance as its stock of trees has been worked out, and the Territory of Colonias has become the most productive rubber region in Bolivia Rubber trees are found in large quantities along all the rivers of Colonias, including the Acre, Abuna, Orton, Madre de Dios, and their tributaries. Development in all these districts is comparatively recent, the rubber resources of the Abuna not having been worked until 1904. Most of the gomales, or rubber plantations, of El Beni are along the lower reaches of the Beni and the Mamore, in the Province of Vaca Diez, and to a lesser extent in that of Yacuma; there are also important fields in the Itenez Basin The rubber districts of Santa Cruz are located in the Provinces of Nuflo de Chavez and Velasco, and lie mostly between the San Miguel and the Paragua. San Ignacio and Concepcion are the chief centres of the rubber business of this part of Bolivia. The rubber industry of the Department of La Paz is restricted to the Province of Caupolican, and to a much less degree to those of Larecaja, Munecas, and Nor Yungas. The comparatively unimportant gomales of the Department of Cochabamba are situated in the Province of the Chapare in the basin of the river of that name and in the basin of the D'Orbigny

The highest grade of Amazonian rubber, known as Para fine, is derived from the hevea tree, which stands from 30 to 40 metres (metre 3.28 feet) high and may attain a diameter of a meter or even more An inferior grade of rubber is extracted from the caucho tree (*Castilloa elastica*) The product is sold on the market as caucho The caucho trees that are worked are generally from 30 to 50 metres high Contrary to the procedure used with the hevea, the caucho must be cut down in order to obtain the sap. The rubber known as ceara is extracted from the manicoba tree (*Manihot glaziovii*), which is also found, though not in great numbers in the Bolivian forests

The rubber trees do not exist in solid stands, but are found scattered throughout the general forest The belts along the rivers where they occur seldom extend inland more than 10 or 12 miles The tree prefers low ground in the neighbourhood of swamps and watercourses, where the moisture is retained in the ground throughout the year, and it appears to thrive best on land that is inundated about once every three years

The methods of gathering the rubber used by the Bolivian seringueiro, or extractor and coagulator, are much the same throughout the rubber districts of the Republic, though some improvements have been made in the procedure of extraction during the last few years. Each seringueiro or picador is assigned an estrada of 150 trees, which he is to work. Every day during the season he goes the rounds of his estrada, beginning his labours about daybreak. With a long-handled hatchet he makes from 6 to 12 incisions in the bark of the tree as high as he can reach on the trunk, and under each incision he places a tin cup into which the latex or sap flows. It requires about three hours to make this first round of the estrada, and after a short rest the seringueiro makes a second round of the trees to collect the latex from the cups. He empties the latex into a bucket and carries the proceeds of his morning's work to his encampment for coagulation, which is accomplished by a smoking process.

The contents of the bucket are poured into a basin and the latex poured over a stick which is revolved in the dense smoke produced from hard palm wood or palm nuts burned in a small oven. The latex coagulates rapidly in this smoke and gradually forms a ball, which is taken off when at a convenient size, about 40 or 50 pounds, and placed to dry under a roof of palm leaves. In this way the characteristic Para rubber balls are produced, and an incision will show the layers made by the turning of the rubber during the process of coagulation.

Each day the workman makes the incision on the tree an inch or two lower down on the trunk until the roots are reached, when the tree is left to rest until the next year Trees are worked continuously during the rainy season of each year for two or three years, and then are not worked for an equal period The life of a tree which is under exploitation is from 15 to 30 years, largely depending on the care taken in making the incisions. Those made by a careless picador will reach below the bark of the tree and injure its vital parts, thus causing it to die before its natural term of life.

Of late years experiments have been made with the so-called herring-bone system, which is used on the plantations. By this method a knife with a short convex blade just wide enough to enter the bark is used to make a long, vertical incision about 4 feet in length. A number of parallel lateral incisions are then made on each side of and terminating in the central incision The latter serves as a kind of trough through which the latex from the lateral incisions flows down the side of the tree and out through a small spout into a bucket. This method preserves the tree from the dangers which result from the deep incisions made by the old system in which the hatchet is used.

On the arrival of a consignment of rubber at Manaos or Para, a bolacha or sample ball is cut through several layers with a knife for the purpose of classifying the lot There are eight classes, according to this preliminary inspection, though the rubber is generally shipped as of two classes. The eight classes are as follows: Fina, fina flaca, entrefina, entre-fina-flaca, sernamby en rama, sernamby virgen, sernamby de caucho, and caucho. However, these are exported to the foreign market as fine or ordinary. The rubber known as fine hard Para is the prime product of the latex of the hevea. Sernamby is second quality rubber, and, though a product of the hevea, it contains impurities which mar its value; it is sometimes made of the residue after the preparation of the fine Para. If rain has fallen in the cups while the latex is being collected, the product will be classified as sernamby. Caucho is the product of the caucho tree and is altogether a lower grade of rubber.

The fact that Bolivian rubber is either classed as Para or Mollendo on the foreign market does an injustice to Bolivia, against which Bolivians have long protested. Amazonian rubber is known to the rubber trade only by the ultimate port of shipment, which is generally either Para, Brazil, or Mollendo, Peru. The rubber from the country about the lower reaches of the rivers is exported through Para, and that from the Beni headwaters is sent out through the Pacific port of Mollendo.

The Amazonian rubber industry, including, of course, that of Bolivia, has been seriously threatened by the rapid development of the East Indian plantations. Though realizing the menace, the South American rubber interests, says the Trade Commissioner, appear to have done little to meet it. A few Bolivian companies have considered the establishment of plantations, and at least one prominent rubber grower has actually planted some trees, but the movement has progressed no further. Meanwhile, owing to their more economical methods, the plantations have rapidly gained control of the world rubber market.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, DECEMBER 19.. Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Graduates' Meeting.) Mr. C. Poole, "Worm-Gearing." (Yorkshire Branch), Sheffield, 7.30 p.m. Dr. W. H. Hatfield, "Recent Developments with regard to Alloy Steels and their Uses" (North Western Branch) Memorial Hall, Albert Square, Manchester, 7 p.m. Mr. G. Mitchell, "Conveying and Elevating Machinery." 2. Mr. R. E. Knight, Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators."

University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "Recent Researches on the Biology of Bacteria." (Lecture IV.).

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. T. E. Colcutt, "A Plea for a Broader Conception of Architectural Education."

TUESDAY, DECEMBER 20.. University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "Recent Researches on the Biology of Bacteria." (Lecture V.)

Sociological Society, 65, Belgrave Road, S.W., 8.15 p.m. Mr. C. Dawson, "The Life of Civilizations."

Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Mr. R. Pezzani, "Mauritius."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. C. R. C. Pettey, "The Chamonix Valley."

WEDNESDAY, DECEMBER 21.. Meteorological Society, 49, Cromwell Road, S.W., 5 p.m.

Geological Society, Burlington House, W., 5.30 p.m.

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. A. Dalgleish, "Trade Boards."

United Service Institution, Whitehall, S.W., 3 p.m. Captain E. W. Sheppard, "German Views on the Marne Campaign."

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FRIDAY, DECEMBER 23, 1921

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C (2)

NOTICES.

SEVENTH ORDINARY MEETING

WEDNESDAY, DECEMBER 14th; MR. EDWARD DENT, Member of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Chari, N. S. T., M.A., Calcutta, India.
Gibson, Mrs. Marion Campbell, Perth, West Australia
Gwyn-Williams, Captain R. H., O.B.E., M.C., Balaghat, Central Provinces, India
Hardcastle, Charles Henry, Bombay, India.
Harding, Henry George Alan, F.C.S., North Sydney, N.S.W., Australia.
Lahiri, Purna Chandra, L.M.S., Dibrugarh, Assam, India
Saksena, Ram Babu, M.A., LL.B., Saharanpore, United Provinces, India.
Stubbs, Roy Wilson, Karachi, India.
Sturrock, George S., Lahore, Punjab, India.
Watson, Edwin Alexander, Calcutta, India.

The following candidate was balloted for and duly elected a Fellow of the Society:

L. D. Varshnei, Bahjoi, India.

A paper on "Trade with the Netherlands East Indies," was read by Sir Walter Beaupré Townley, K.C.M.G., Minister to the Netherlands, 1917-19.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF HOWARD LECTURES.

The Howard Lectures on "Aero Engines," by ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., have been reprinted from the *Journal*, and the pamphlet (price 4s.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been reprinted and are still on sale can also be obtained on application.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 4th and 11th January, 1922, at 3 p.m., by Mr. William Reginald Ormandy, D.Sc., F.I.C., on "Clay: What it is—Where it comes from—and What can be done with it." The lectures will be illustrated with experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

CASES FOR JOURNALS.

Cases for keeping the current numbers of the *Journal* are now obtainable. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s.* 6*d.* each, on application to the Secretary.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s.* each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES AND INDIAN SECTIONS
(Joint Meeting).

FRIDAY, NOVEMBER 25TH, 1921.

BRIG.-GEN. LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., in the Chair.

THE CHAIRMAN, in introducing the author of the paper, said that Mr. Ashbolt came from almost the furthest part of the British Empire, measured in miles, from where he now stood, and, therefore, appreciated on that account the necessity for more rapid communications between the mother country and the great Dominions over seas Last summer, when the question of airships and airship personnel was being dealt with at the Imperial Conference, and afterwards, he had been one of the keenest supporters of airships; and to Mr Ashbolt belonged a great deal of the credit for such concessions as had been obtained on that occasion, although they had not, at that moment, seemed to amount to much. He was sure that Mr. Ashbolt would send his audience away with the firm conviction that the British Empire could not afford from any point of view to be left behind in the development of aviation. It was a painful thing to have to admit, but there was no doubt that other nations, like the United States, Japan, France and Germany, and even Spain, were doing far more in regard both to short distance and long distance aviation than we were That was quite wrong for a great Empire, and especially wrong for the British Empire, which had, at any rate a the end of the war, attained a pre-eminent position in aviation.

The paper read was:—

AN IMPERIAL AIRSHIP SERVICE.

By A. H. ASHBOLT,
Agent-General for Tasmania.

The announcement of the British Government that they had decided to cut the airship out of the scheme for defence and to limit aerial military operations to the aeroplane was not altogether unexpected, but the subsequent intimation that unless satisfactory arrangements could be made for the utilisation of the existing ships and plant in Great Britain for commercial purposes they would be destroyed and the entire service and organisation disbanded came as a great shock, not only to the personnel of the service in question, but to the general public. Further, no suggestion was made to utilise the ships and organisation for Imperial developments, this phase of the matter having apparently been overlooked or not taken into consideration. On reading this notification its Imperial possibilities struck me immediately, and I interviewed the Right Honourable Winston Churchill, Secretary of State for the Colonies, and Sir James Stevenson, whom Mr. Churchill called into consultation. The result was the submission on May 9th last of a proposal, addressed to the British Government, to initiate an Imperial Service, and after further negotiations, the Air Ministry published a communication, No. 675, on May 31st setting out the terms and conditions under which they were prepared to offer the fleet of ships, material and information acquired. Now, to acquire the existing fleet, sheds, plant and stores, together with the knowledge gained by our airship personnel, cost the British public about £40,000,000, so that if we break up the plant and organisation with its most important technical staff, etc., and restart in say four or five years to rebuild the existing fleet of ships, sheds, plant, accumulate the same stores and re-acquire the present knowledge of the existing personnel, would cost about £12,000,000. This fact, plus its use as a Naval auxiliary and the Imperial necessity for more rapid communication between the various parts of our Empire, and also the further fact that the British Empire is so advantageously placed over so much of the globe that we can if desired build our aerial stations so as to refuel on our own soil throughout the length and breadth of the suggested routes, makes the decision inexplicable and entirely lacking in that vision which should characterise the judgment of our statesmen.

No truer summary of the position could be given than that of the Prince of Wales in his speech at the annual dinner of the Royal Colonial Institute, where he drew an analogy between the spreading of the Roman Empire and its subsequent disintegration through insufficient communications. Are we to stand still and take no notice of the evolution going on around us? Major-General Sir F. H. Sykes said the other day:—"The evolution of civilisation "is first the phase stretching back into the "roadless mists of unrecorded time—of "their threads of intermittent barter—the "era of roads which gradually linked the "important areas of the Roman Empire—

"The epoch of the more economical water-"way with Venice as the pivot—The age "of ocean sailing which brought England "to the fore—Then as man was becoming "used to the great possibilities indicated "by the Elizabethan adventure, came the "crescendo of iron, of steel and of steam." Are we to say that the steamships of to-day, magnificent as they are in every respect, mark the final means of personal communication between the component parts of our Empire? And yet that is what we contemplate if the decision of the British Government is carried out. Its possibility can only be brought about by the mental stagnation or indigestion which seems to be one of the unfortunate aftermaths of the Great War. To revivify that mentality is one of the objects of this paper, and for this purpose I propose dealing under different headings with the project to launch an Imperial Airship Service.

First, I would like to remind you that in 1913 airships were transferred to the Admiralty, but it was not until 1917 that any construction programme was commenced. In the summer of 1918 the Admiralty contemplated a programme which provided for the building of 16 rigid airships of R 33 class or better. In 1919, however, before these vessels were completed, the control of airships passed from the Admiralty to the Air Ministry. At the time of the transfer it was arranged that the Admiralty requirements would be met by maintaining one airship in commission and building a new airship every two years. Subsequently the decision to discontinue entirely airship operations was come to, and looking at the position from the point of view of a Government anxious to reduce expenditure and cut out everything but actual necessities, I can to some extent sympathise with the decision, but I am strongly of the opinion that such a saving is not commensurate with the loss by the Navy of their airships nor with the loss of closer Imperial relations which an Imperial service such as I suggested, would establish. To me it seems that all that was required to develop its Naval and Imperial possibilities was a reorganisation which would have permitted experiments and developments of airships on these lines instead of letting them continue as part of the Air Ministry, which was necessarily dominated almost entirely by military interests. It was, and is, a curious fact that so many of the real heads controlling aviation matters have never made themselves conversant with the actual detail of airships, and in many instances have not even had a flight in them. If ever there was a case in official circles of the "unwanted child," they had it in airships. Bandied from pillar to post with no definite constructive policy and no one in high command with sufficient interest to carry out the proposals of the late General Maitland and the enthusiastic group of officers banded with him, or to insist upon experiments on consecutive and developmental lines meant that the work done was of a desultory character at a cost altogether out of proportion to the visible results achieved. Admitted that members of the personnel were acquiring considerable knowledge in connection with the flights from the mast at Pulham, there was no definite attempt at flying between termini. All the work centred round the one mast and the knowledge acquired was apparent to but very few. Admitted, again, that there is very little real difference in flying from the mast-head at Pulham and re-berthing some hours later, from flying from Pulham and re-berthing at the Riviera or some other Continental centre, there is this fact that in the first case no public results are achieved, whilst in the latter a distinctively definite object has been gained. The Right Honourable the Prime Minister for Australia said on one occasion :—"I do not want to fly round "a saucer. Fly me to a point on the journey "to the Antipodes and I will then agree "that you have made a definite advance "in aerial navigation." Some eighteen months was, unfortunately, lost in what might be termed desultory flying at an inordinately high cost.

The result of my proposal and subsequent negotiations was that the matter was then placed upon the agenda paper for consideration at the Imperial Conference of Premiers called for the end of June, 1921. The Imperial possibilities of such a service were then for the first time realised by the Press and British public, the former, particularly *The Times*, giving very great publicity to the suggestion, which also received considerable favour from the public in the Overseas Dominions, especially Australia, New Zealand and South Africa. At the Conference the question was thrashed out at a great length, but before discussing definite proposals the Premier's Conference

referred the matter to a special commission comprising the following individuals:—

Captain the Rt. Hon. F. E. Guest, C.B.E., D.S.O., M.P., Secretary of State for Air (Chairman).

Lord Gorell, C.B.E., M.C., Under Secretary of State for Air.

Air-Marshal Sir H. M. Trenchard, Bt., K.C.B., D.S.O., Chief of the Air Staff.

Major-General Sir F. H. Sykes, G.B.E., K.C.B., C.M.G., Controller-General of Civil Aviation.

Sir G. L. Barstow, K.C.B., representing H.M. Treasury.

Sir James Stevenson, Bt., representing the Colonial Office.

J. H. Lovell, Esq., representing the India Office.

Sir Ross Smith, K.B.E., representing Australia and New Zealand.

Colonel the Hon. H. Mentz, representing South Africa.

L. V. Meadowcroft, Esq., Secretary.

This commission reported under date of July 26th, 1921, *inter alia*:—"Although "the existing fleet of four airships when put "in commission will enable a scheme of "Imperial communications to be begun, "it is insufficient to enable a complete "scheme to be developed." The report then goes into the question of developing the service by (*a*) the Governments concerned, or (*b*) commercial enterprise alone. Estimates showing that any experimental service initiated must be at least for a period of two years are also given by this Commission. No question whatever is raised as to the unsuitability or impossibility of establishing such a service; its practicability and Imperial necessity are accepted by them without qualification or argument. The report confines itself largely to the financial side of the question, and it is entirely on this point that the question of the establishment of the service, and British supremacy in the commercial airways of the world, is at stake. The outstanding question is how is the necessary money to be found in these days of stringency to provide for a period of at least two years, during which the commercial possibilities and the Imperial character of the service can be tried out? In my opinion Government assistance is necessary. In pre-war days one could always rely upon obtaining the support of a number of what might be termed commercial adventurers in the interests of themselves and their Empire, but to-day the money market is such that this free money is not now available. However, the spirit of adventure still rises in our breasts and even under to-day's chaotic financial conditions the money required can be obtained provided the Governments concerned give the service practical support by the diversion of a portion of the mails and agree to a subsidy of £500,000 per annum, half payable by the British Government and half by the Dominion Governments.

In view of the immense benefits that the successful establishment of such a service would confer upon the Empire and quite irrespective of its potential benefit to the Navy in case of war, it is not asking much from the Governments concerned, particularly when one bears in mind the subsidies which have been previously paid by different Governments for the establishment of mail services by steamers and advances at low rate of interest for the construction of special vessels, such as the "Mauretania" and "Lusitania." Personally I am pleased to think, from conversations with responsible members of the British Administration, that England will agree to such a contribution or subsidy as I suggest, for a term of years, provided that the Overseas Governments are prepared to share similarly and give their whole-hearted support to the service when established. I believe, too, that the British Government would be willing to make a cash contribution for a term of years in addition to the subsidy, provided they are thoroughly satisfied that the work to be done is a genuine attempt over a period of not less than two years and that the money will not be frittered away in desultory experiments without definite aim or policy.

In the meantime, we are all anxiously waiting to hear details of proposals placed before the Overseas Dominions by the Premiers of Australia, South Africa and New Zealand, and by the representatives of India. The Prime Minister of Australia is the first to come into the field and make good his promises and speeches at this end. Immediately on his return to Australia he arranged to place £500,000 on the estimates for the coming year for aerial matters. This, of course, includes provision for military aircraft in Australia, together with subsidies for the establishment of Interstate Aerial Services in various parts of the Australian Commonwealth. At the same time he has also proposed that Australia

should immediately set aside £250,000 to cover expenditure during the suggested two years for the experimental service recommended to the Conference of Premiers in London last July by the Imperial Air Communications Committee. Such prompt action is very gratifying to those of us who had the pleasure and opportunity of discussing air communications with Mr. Hughes during his recent visit to London. It now only remains for the Premiers of South Africa and New Zealand and the delegates for India to put forward similar schemes on behalf of their countries and then jointly request Great Britain to combine forces and the money can then be found to establish that Imperial Service which will make the biggest revolution in shortening time and distance between our several and separate entities, enabling Englishmen to know their Empire and Overseas representatives to sit in conference at frequent intervals with the senior partner of our Empire Company.

In my remarks I am assuming that the flights of the Zeppelins during the war, the voyage of the German L59 from Bulgaria to Central Africa and back, the historic flight of R34 to America and back, together with the desultory flying in Engand since the Armistice have, notwithstanding the loss of the R38, placed beyond all question of doubt the suitability of airships for commercial services over long distance routes. Before the introduction of the mooring mast the difficulties of shedding and unshedding such craft put them, in my opinion, completely out of commercial possibilities owing, first, to the large number of hands necessary to handle such vessels at every departure and arrival, secondly, to such departures and arrivals being entirely subject to weather conditions, thus reducing the number of days upon which sailings could be made and entirely preventing a definite schedule ; and, thirdly, to the fact that notwithstanding precautions against flying upon unsuitable days every rigid airship destroyed prior to R38, and exclusive of damage through hostilities, was lost on the ground and not in the air. As an indication of the conversion from a non-commercial to a commercial proposition, the following figures of flights from Pulham demonstrate the difference made by the introduction of the mooring mast. From the 1st February to the 30th June, 1921, 164 flights were made from the mooring mast, whereas at Howden, without a mooring mast and during the same period, it was only possible to get the ship out of the shed and fly on 30 occasions. The staff required to shed a ship even in light winds runs into about 350 hands; that to moor a ship at mast-head ten hands.

A considerable amount of money has been spent by the British Government in connection with meteorological matters, which necessarily play a very important part in aerial navigation both for aeroplanes and airships. The knowledge gained and the continuous reports from the various stations established, will be available for airships, and in the course of a few years air currents will be charted and as well known as surface winds. In his memorable flight to America in R34, Major Scott reports the great differences he found in currents and strength of wind between the surface and heights, say, of 2,000 feet and over. He found that in many cases of shallow depressions an adverse wind of as much as 45 knots did not extend above 5,000 feet from the surface. It is more than likely, therefore, that the monsoons of the Indian Ocean do not attain any great height, and it is quite likely that when these winds are against the vessel a rise of a few hundred feet may place the ship in quite a different current and minimise the reducing effect of plugging into a dead head wind. In considering airship speeds the effect of the wind must be taken very fully into consideration. For instance, if a ship driven at 50 knots speed finds itself up against a wind of 40 knots the net progress is 10 knots only. Therefore, if the vessel had to cover, say, 100 miles and presuming the 40 knot head wind continued, it would take her 10 hours to cover that 100 miles, although she would have consumed fuel equivalent to flying 500 miles in calm weather. Therefore, under these conditions the ship has wasted 400 air miles. If, however, the vessel was capable of maintaining a speed of 60 knots in calm weather her progress would then be 20 knots per hour instead of 10 with the lesser power. Consequently she would only take five hours to cover the 100 miles, making her fuel usage equivalent to 300 miles, a wastage of 200 air miles instead of 400 air miles as first indicated. It is common knowledge to-day that the state of the weather on the surface does not give much indication of actual conditions at, say, 2,000 feet up and more. Once meteoro-

logical arrangements are complete and the required information available for communication to airships by wireless, it should be a criminal act for any captain of an airship to permit his ship to run into cyclones or other extreme wind velocities. In fact, it should be a regulation of future airship companies that any commander running his ship into such conditions should automatically be suspended or dismissed on arrival.

Since 1914 to the present date 134 rigid airships have been constructed, and it will be interesting to record their growth in size and the increase in proportion of disposable lift. The details are as follows :—

Type.	Gas capacity cubic feet.	Gross lift in tons.	Disposable lift in tons.	Percentage of disposable lift *v.* gross lift.	
German				%	
L3	794,600	24	8	33	Built 120
SL3	1,146,000	34	12	35	
L20	1,260,000	36	16	42	
SL20	1,978,000	60	32	53	
L60	1,972,000	60	36	60	
L71	2,420,000	73	47	64	
L100	3,816,000	115	76	66	designed only.
British.				%	
R23	900,000	27	7	27	Built 14.
R80	1,200,000	36	14	39	
R33	1,958,000	59	26	44	
R36	2,101,000	63	32	50	
R38	2,724,000	82	50	61	

It is readily seen what a dominating position Germany has in this table, but for the moment she has no vessels, as under the Treaty of Versailles all airships in possession of that country at that date were destroyed by or distributed amongst the Allies. Exclusive of vessels destroyed through warfare, there is no record of any collapsing or crashing with loss of life until the great misfortune of R38. Admittedly many vessels were lost, but as I have said invariably on the ground and not in the air. In the air there is no doubt they are amongst the easiest vessels in existence to navigate and control, but on the ground they are unwieldy, and with any wind are apt to get out of hand, particularly when they are being shedded. This difficulty, however, has been practically overcome by the introduction by Great Britain of the mooring mast. The loss of R38 is of so poignant and recent occurrence that details of this crash are unnecessary, but I would like to place on record my own personal appreciation of several of those gallant gentlemen particularly General Maitland, who lost their lives on that occasion. In my own mind there is no doubt as to the cause of this disaster. The court of inquiry set up by the Air Council reported on October 8th, 1921, "That on August 24th, 1921, at or about "5.38 p.m., the Airship R38, whilst flying "at approximately 1,200 feet over the "Humber in the neighbourhood of Hull, "broke into two parts, due to failure of "the structure in rear of the after-engine "cars when being subjected to control "tests." The court also drew attention to the fact "that R38 was designed in "August, 1918, in the Department of "Airship Construction, Admiralty, to meet "requirements which appear to the Court "to be greatly in advance of those of "previous British airships. That require-"ments as to maximum height and speed, "together with the limits in length imposed "by the only available construction sheds, "necessitated the utmost economy in hull "weights and materials. Many new features "were introduced in the design, and it "appears evident that in some cases there "was a lack of vital aerodynamical in-"formation as to the effect of these modifica-"tions on the strength of the structure." There is no doubt, in my opinion, that the vessel in her control tests was asked to do considerably more than the calculated stresses of this experimental ship warranted. That some uneasiness was felt regarding the design of the vessel is evidenced by the

very terms and conditions of the contract between the British and American Governments for this ship. Without going into elaborate detail the transaction was arranged first by negotiations between the two Governments respectively to sell and purchase the ship in question. Owing to its experimental design the American Government asked for extensive tests to be conducted at the expense and risk of the British Government. This was refused, owing to the stiffness of the tests required by the Government of the United States of America, the final result being that the ship was completed on the understanding that she was purchased at an arranged price by the United States of America, subject to the satisfactory conclusion of tests to be carried out in the presence of officers of both Governments, and in the event of accident the cost to be equally divided between the two parties. The result is that the monetary loss occasioned by the loss of R 38 is equally borne by the British and American Governments. This seems to be fairly conclusive evidence that the design was largely experimental, and it is more than probable that if the vessel had been asked to undertake the normal trials to which these vessels had been previously subjected, the total loss would not have occurred. It has occurred, however, and there is no doubt whatever that every precaution will be taken to prevent a recurrence of such an appalling collapse. This personal opinion is also strengthened by a conversation I had with Mr. Campbell, the designer of the ship, who lost his life with the crew on August 24th. In connection with the proposals for an Imperial Airship Service that I was placing before the British and Dominion Governments, I visited the ships and sheds at Pulham and Cardington. When at Cardington the R38 was in shed undergoing some slight repairs necessitated by the previous flight. Mr. Campbell showed me the principal structural differences between that ship and R36 and the German Zeppelin L71. Subsequently, on thinking matters over, I felt uneasy on the subject of building commercial vessels on the lines of R38, and had a further interview with Mr. Campbell at my office in London. I expressed my doubt on this point and asked him whether in the event of an Imperial Service being established he would design on the lines of R38. Before I could express myself further, Mr. Campbell exclaimed, "Good God, man, no! R38 was "specially designed in accordance with "Admiralty instructions for purely war "purposes to over-fly and out-fly all "existing Zeppelins. We have, therefore, "built her as light as possible to attain "maximum heights, and she has very "considerable engine power. When we "build for commercial work maximum "height and maximum speeds are not "essential. With a war craft, if she serves "her purpose during hostilities for, say, "six months, she has achieved all that one "would ask from her, but for commercial "purposes you want strength and stability "instead of lightness and height. For "commercial purposes we would simply "elaborate R33 and R36." I then said, "Well, on a vessel of similar size to R38, "what additional structural weight would "you put into this size vessel for com-"mercial purposes?" To this he replied:— "Between 25 and 30 cwt. additional girder "strength. With that strength and the "knowledge and experience obtained "through recent mooring tests we can "build you a boat that will be absolutely "safe, suitable for flying in any weather "and one that will last for a good many "years."

Bearing in mind therefore, the report of the court detailed above, together with the position as detailed in the conversation with the designer of R38 and myself, it is very essential that not only the Governments and the commercial interests, but the public at large, should realise the difference between vessels constructed for war and those constructed for peace. This might be further exemplified by realising that even in the Navy with the experience of 50 years behind us mistakes in design have been made. Do not overlook the fact that in Jane's "Fighting Ships" he records that the famous "Hush Hush" ships "Furiosis," "Courageous," etc., were all built to the same design at a cost of about £6,000,000 each. They were estimated and designed to steam between 40 and 43 knots per hour, but utterly failed on their steam trials to stand the water pressure on the bows, owing to the structural weakness through bad designing. The bows collapsed when the vessels were driven at full speed on trial trips. They were of course subsequently strengthened and no loss of life or accident occurred; but what I want you to realise is that here, after all our 50 years'

Naval experience, a fresh design failed to stand up to its calculated strengths, an identical position so far as I understand it to that of R 38. Even after strengthening these vessels they were unsuitable for their specific purposes and were converted into vessels to carry and launch aeroplanes, each vessel having a capacity to launch 10 planes. But at the prime cost of £6,000,000 each they were very costly vessels for such a purpose, more particularly in view of the fact that a vessel of the strength and design of R 36, costing then about £350,000, could carry and launch seven aeroplanes.

WAR SERVICES.—There is no doubt that the comparative failure of the Zeppelins in the War was a great disappointment to Germany and the knowledge of their present limitations as an offensive arm is no doubt the reason why our own military authorities have discarded airships from their list of armaments. It must be remembered, however, that owing to the mooring mast not having been invented, Zeppelins were only able to go on their bombing raids in fine weather. If Germany had had masts she would not have attempted raids on London in fine weather when visibility was good and every facility afforded to Great Britian for aeroplane flights and gun practice. With a mast the Germans could have flown on dull cloudy days and flying in the clouds could have been over London unperceived and practically undiscoverable, locating themselves by wireless direction from their bases in Germany. Under these circumstances it is doubtful whether we ever could have touched them. Their partial failure in the recent War should not be allowed to overshadow the great help they were to the German Fleet for scouting purposes and it may not be an exaggeration to say that the German Airship Service helped to save the German Fleet from annihilation at Jutland. There is no doubt whatever that they saved the German cruisers raiding our East Coast on more than one occasion. Admiral Lord Jellicoe, in his book, states that one airship was worth at least two cruisers, even with the limited number of days they were able to fly for the reason already stated. It seems to me, therefore, that so far as our Naval Defences are concerned we must not lose sight of the possibilities provided by airships for scouting and other purposes. At present we build fast cruisers at a huge expense, but even the fastest cruisers can barely obtain 50 % of the speed obtainable by airships, while the latter's cruising height so extends their visibility as to place them for scouting purposes well ahead of any floating vessel yet designed or built. The procuring of Helium or some mechanical means such as air cushions that will prevent airships catching fire will add to their sphere of usefulness in time of war beyond all measure. When such a ship materialises, as it undoubtedly will, it will then be a very moot point whether the present superiority of an aeroplane for war purposes is not challenged. To-day, however, we are not concerned with this phase of airships, but the point must not be overlooked. There is no doubt that continued use for commercial purposes will develop many improvements which will be of immense use in commerce or war, particularly now that the scene of action is changed from the North Sea to the Pacific Ocean. In the North Sea our Fleet was under our eyes and within immediate touch, but in the Pacific Ocean or some other far flung portion of the globe, it will be by the air alone that we shall be able to get in personal touch with our Commanders. Airships with their extended scope of action are immeasurably superior to aeroplanes for this class of work. They also have many other uses, a few of which I will briefly refer to :—

(a) It may be of great value to a Commander-in-Chief to know that no hostile fleet has passed a certain channel, e.g., the Great Belt or the Straits of Gibraltar. If a passage is unwatched for even a few hours a hostile fleet may be through, and the Commander-in-Chief must take that into his calculations. No craft is so suitable for watching work as airships, as they can stay for days on one position observing a much larger area of water than surface scouts and immune from the risk of submarine and mine. They are also cheaper than surface craft, as is easily seen when you realise that a modern airship can keep about 100,000 square miles under observation per 24 hours and that it would take at least six surface craft to observe the same area and even then not as efficiently. Again, if lost for any reason only about one-tenth of the number of officers and men are lost compared to the total loss of a light cruiser.

If filled with non-flammable gas, or gas

armoured, she can only be destroyed by a hit from a big gun or a large charge exploded in close proximity.

(*b*) *Anti-Submarine Work.* The use of airships for this work may be taken as proved. For many months no convoy escorted by airships was attacked. The only fault they possess is that they are slow in getting at a submarine sighted up wind. To meet this case at the end of the war, airships on coastal convoy work were being fitted to carry a fast aeroplane which could be slipped to attack immediately on sighting the enemy. For submarine hunting by using hydrophones the airship is specially suitable as there are no water noises from the hull, such as exist with surface craft, to interfere with listening. Again, to assist submarines an airship can be taken in tow and keep in telephonic communication with the submarine under water.

(*c*) *Mine Clearing.* Some mines are exploded by the noise of a ship's propeller, some by bringing a mass of metal over them. These are difficult and dangerous to clear by surface craft, but an airship can tow an instrument over them designed to imitate the beat of propeller, etc., and so explode the mine. Airships were used to assist trawlers to find and buoy mine fields and to follow our own mine layers to see that the mines took their depth properly.

(*d*) *Bomb Dropping.* The use of the ordinary bomb dropped vertically is well-known. The U.S.A. Army Air Service have proved that one ton of high explosive will destroy a battleship if dropped close alongside and exploded under water. The next development will be the Wireless Controlled Gliding Bomb. Gliders up to half a ton have already been dropped from airships. Captain C. Ryan, R.N., has made a motor launch (500 h.p.) which has been stopped, started and steered very successfully by wireless from the air. It is only necessary to put the essential gear in a glider carrying a ton of explosive, slip it and steer it by wireless till it hits a ship and falls into the water alongside, exploding there. From a height of 10,000 feet it should be possible to hit a ship 30,000 yards away, i.e., out of gunfire. For longer ranges it will eventually be possible to use an unmanned aeroplane instead of a glider, the weight of engine correspondingly reducing the explosive carried.

I look on this as a most important possibility. It definitely threatens the existence of the capital ship and can only be met by aerial defence of some sort. Therefore, some portion of our Navy must fly.

(*e*) *Transport Work.* Cheap non-rigid or semi-rigid airships not necessarily requiring masts can now be built to carry loads of seven tons slung from a single point for about 200 miles at 50 m.p.h. This weight means 70 men, or guns, or stores, etc. In a country with bad communications it would be invaluable to the Army to take up stores and provisions and bring back sick and wounded. They could also be used for transporting aeroplanes for military work. The R.A.F. prefer to pack their aeroplanes in crates even for despatch to Ireland. It takes about three months to test an aeroplane in this country, un-rig, pack and despatch by sea to Egypt, re-rig and fly it. An airship of to-day could take 10 aeroplanes to Egypt, rigged ready for flight in three days. Further, with a mother ship fitted with mooring mast and apparatus for making gas, airships could go to any storm centre in any part of the world and patrol disturbed districts.

The establishment of such an Imperial Route would therefore be of great value, both in time of peace and war. During peace the cost of installing and maintaining such a chain of stations for war purposes alone, practically places it beyond the bounds of possibility, but such a chain established for commercial usage would undoubtedly be availed of by military machines in the various vicinities, whilst in case of war the whole fleet, personnel and plant would immediately be available as a going concern. During the peace period, too, facilities could be afforded to train members of the Naval Service.

With the reduction of our Navy which followed the Armistice, the further reduction proposed by the Washington Conference and with the knowledge of all the above possibilities, is it conceivable that the Naval Authorities would have agreed to transfer Naval Airships to the Air Ministry, if they had known that within a short period the Ministry would discontinue airship services and concentrate upon aeroplanes?

In considering estimates detailed in the appendix it should be borne in mind that the probabilities are that the items on the expenditure side are maximum rates and that experience in commercial flying will enable considerable reductions in several items to be made. For instance :—

(*a*) At present when coming down a percentage of gas is lost through valving. Experiments were being made to use such gas for power purposes and there is every reason to believe that the experiment discontinued when the Government closed down would have made practical this proposition. The satisfactory solution of this difficulty means a double saving, inasmuch as instead of wasting the hydrogen it is utilised for power production and its utilisation lessens the consumption of petrol, reducing the quantity to be carried as a reserve, thus adding to the commercial lift.

(*b*) So far, airship engines are identical with or converted aeroplane engines. There is no doubt but that the commercial adoption of airships will lead to the production of engines specially designed for this class of work and there seems no reason why the evolution of engine practice in connection with submarines should not be repeated here. The early submarines were petrol driven. Then kerosene came along and finally the last submarines were using crude oils. It is almost certain that the same results will be achieved in airship engines. Such an evolution has a two-fold effect, inasmuch as running costs and the risk of fire both decrease as such changes become effective. Kerosene is not nearly so inflammable or as costly as petrol and crude oil is still cheaper and practically non-flammable.

(*c*) Another line of research to cheapen power is the admixture of hydrogen with all three fuels mentioned, viz., petrol, kerosene and crude oil. Experiments so far indicate that the burning of hydrogen with these three fuels adds considerably to efficiency and consequently reduces expenditure.

(*d*) The cost of hydrogen gas in the estimates referred to is taken at 10*s*. per 1,000 cubic feet, but British manufacturers of gas plants state that they are prepared to contract to erect plants to produce hydrogen gas at 6*s*. per 1,000 cubic feet, with a possibility of an even lower cost.

(*e*) Overhead expenses at air ports or bases can be considerably reduced. At present the entire cost of maintenance is included in the estimated expenditure, but it is fairly obvious that these bases, which for some years, at any rate, would not be fully utilised by the airship services, could be utilised for private work. These bases must of necessity have well fitted ships and it should not be a difficult task to secure sufficient work from the vicinity to keep them well employed, thus effecting a considerable reduction in this portion of the total running cost of a ship. Then as the number of airships increases overhead expenses automatically decrease proportionately.

In addition to the possible running cost reductions already mentioned, it is probable that considerable improvements in hull construction will take place, and reference to a few of these matters will be of interest to those considering the scheme in its Imperial character. They are as follows:—

(1.) Fuel Containers. There is no doubt that the breaking of the girders of R38 caused some of the petrol containers to crack or break, with the result that the contents leaking out and mingling with the air were fired either from the exhausts of the running engines or by current from the broken electric leads, and whilst it is unlikely that any future vessel will be constructed that will permit of a similar collapse to that of R38, it may still be desirable, whilst petrol continues to be used, to construct such containers as will minimise this risk. I understand that experiments on these lines are now proceeding in connection with containers for aeroplanes, so it is more than probable that we shall see a solution of this difficulty at an early date. Personally, however, I look to the adoption of the Diesel engine as already mentioned to overcome this risk.

(2) Hull Framing. The earlier Zeppelins were constructed of aluminium. Their rivals, the Schutte Lanz Company, built their vessels of wood as giving superior results to aluminium. The Zeppelin people then came along with an aluminium alloy called Duralumin, and all their recent vessels, as well as those constructed in Great Britain, were built of Duralumin channels. At the close of the war the Schutte Lanz Company had under construction two vessels with framing of Duralumin tubing, these being the first vessels constructed with tubular frames. Unfortunately, they were never completed, as upon the signing of the Armistice they were destroyed by the builders to prevent the information and knowledge of this form of construction falling into the hands of the British. It is considered that a vessel with tubular

framing will, with the same strength, be lighter than a similar vessel built with channel framing. In England we were experimenting with another aluminium alloy, and to-day are actually producing a metal which bulk for bulk is cheaper, stronger and lighter than the Duralumin of Germany.

(3) GAS HOLDERS. The present containers, with their lining of goldbeaters' skin, are very expensive, whilst the supply of the latter is not unlimited. Just prior to the Armistice the British authorities had decided to construct experimental bags with a new synthetic liner instead of the goldbeaters' skin. Unfortunately, upon the declaration of the Armistice the instructions were cancelled, and the experimental bags never completed, but discussing this matter at Cardington on one of my visits, I was assured that the preliminary tests had fully satisfied our technical staffs that they could produce a bag more satisfactory, cheaper and with a longer life than bags lined with goldbeaters' skin.

(4.) ENGINE UNITS. With all commercial airships the different gondolas containing the engines will be detachable and transferable, so that in the event of any separate engine developing trouble during the voyage the gondola with the engine would be detached at the first station holding a reserve unit and there replaced. Then at a general overhaul such a provision will enable a vessel to be re-engined entirely in a few hours, thus reducing the loss of the ship's running time.

In the report of the Imperial Air Communications Committee to the Premiers' Conference, they detail estimates of capital required and working costs to run separate fortnightly services to South Africa, India and Australasia, basing their calculations mainly upon war costs and the period immediately following the Armistice. These figures are the absolute maximum, and in view of the big reductions that have taken place and the further reductions that will take place are consequently misleading. They give the cost of 12 new airships as commencing at £300,000 reducing to £240,000, an average cost of £247,500 each. During the war the Zeppelin Company built their ships at the cost of about £150,000, and since the Armistice have quoted America ships similar to those suggested for the Dominions service at £175,000. There is no doubt that with a block order for anything like 12 ships, upon which the Committee's estimate is based, British firms would be prepared to supply at about £150,000 each. In the calculations detailed in the Appendix the cost of the ships suggested for the permanent Colonial Service is taken at £200 000 each, a figure which I feel sure will provide a margin on actual cost if we are able to place orders for not less than six ships in one contract. Similarly with masts and all ground plant, including sheds. They estimate the cost of new two-berth sheds at £250,000. A very large and well-known firm are to-day prepared to erect a duplicate for about £130,000, and would supply all the steel and erect in England a complete mast ready for use, but exclusive of lift, winches and wire rope for £2,700. The Committee also state that a total capital expenditure of £4,500,000 is required, and whilst it is quite possible that that amount may eventually be wanted, it is not an immediate demand and would not be required if the testing out of the experimental service proved a ghastly failure. It is only the successful initiation of the business that will necessitate the large capital expenditure. Consequently, a considerable portion of the amount stated by the Imperial Communications Committee as required for capital expenditure would only be wanted after the proposal was a proved success. I gather, too, that their estimate for such services is based upon a flying capacity of 2,500 flying hours per ship per annum. In consultation with responsible officers of the Airship Service I learn that with new airships specially built for the service they would probably fly approximately 5,000 hours per ship per annum. I feel sure that the estimate of 2,500 flying hours per ship upon which the Imperial Air Communications Committee base their estimates is altogether too short, and whilst it might be unsafe to calculate upon the estimate of 5,000 flying hours per ship per annum, it should be a very reasonable and conservative estimate to base costs on 3,500 flying hours per ship per annum. It is on this basis that my figures are calculated. Again, presuming that communication with Australasia is first opened up via India, it will certainly not be necessary to provide separate services for Australasia and India, although in the course of time it is probable this would be so. To maintain a fortnightly service to South Africa via Egypt would require two modern airships and a

fortnightly service to Australasia via India would need four modern airships, with an additional ship in reserve. Arrangements would be made to alternate the different ships between the two routes so as to give each vessel as near as possible the same amount of actual mileage. With this understanding it is believed that seven airships would be sufficient to maintain a fortnightly service on the routes indicated. In three or four years time, when the traffic justified additional boats, they could then be easily provided, but in the meantime to include capital for this provision is unnecessary and simply swamps the proposal in its immediate aspect. The safest way to inaugurate the service would be to establish the ground plant to maintain a fortnightly service commencing first of all with the existing airships purely as experimental vessels for such distances as they can be conveniently and commercially utilised. As soon as their limitations are definitely ascertained seven new boats could be ordered with confidence. These could carry on for probably three or four years before further capital expenditure on new vessels would be required.

Owing to the limitations and restrictions imposed upon Germany, that country to-day is not the great and active competitor for the world's routes that she will be when these restrictions are removed. To-day the German personnel are chafing and straining at the leash, anxiously waiting for the moment that they will be free to tackle the world's aerial routes. As a matter of fact, it is questionable whether even with these restrictions Germany is not attempting to hold her position in this matter. A company has just been registered in Spain with an authorised capital of 100,000,000 pesetas, say £3,750,000, to establish flights between Spain and Buenos Aires. Two of the Zeppelin directors are on the board of the new company, and ships are to be constructed on the plans of the well-known Zeppelins. The Spanish and Argentine Governments have agreed to refund the company the cost of the sheds and ground plant at the two termini, such payments being spread over a term of years. The Argentine Government has offered a subsidy of 2,000,000 pesetas (about £70,000) per annum for mails, but it is understood that this amount will be increased, whilst the Spanish Government have also agreed to subsidise, but the amount has not yet been fixed. Germany is also flirting violently with America in connection with the latter's determination to establish their own airship service between the Atlantic and the Pacific. The American preliminary company is at present limited to 30 members, each individual of which is in the front rank of huge American interests, either Government, industrial, banking or oil. I understand they have obtained certain options from both the Zeppelin and Schütte Lanz Companies to permit airship developments within the United States, and that it is more than likely that with the permission of the Allies one of these German companies will construct a large and modern vessel for use within the confines of the United States. Meantime, the United States Government have already erected the largest airship shed in the world at Lakehurst, New Jersey. This shed is capable of accommodating one vessel of 10,000,000 cubic feet capacity or two each of 5,000,000 cubic feet capacity. Sheds are also being erected at Cape May and Langley Field somewhat larger than any at present existing in England and capable of housing ships up to 4,000,000 cubic feet capacity. I understand, too, that the Government of the United States of America are at the present moment also engaged upon the construction of a rigid ship on the lines of the German Zeppelin L49. Once the preliminary company have decided upon a definite policy there will be no lack of money or Government assistance behind the concern to push the business to its maximum lengths.

It has been the experience of the world that all new means of communication or conveyance invariably first pass through a period of scepticism, ridicule and doubt, so much so, that the early stages of any important development have been invariably conducted at a pecuniary loss. It is the realisation of this basic fact that makes the commercial world chary of shouldering the burden for development of airship communications. Owing to the huge amount of money that has to be sunk, not so much on the actual ships themselves, but in the sheds, mooring masts, gas plants and ground equipment, in the different places to be touched at, together with the fact that this extensive organisation will only be utilised in the early stages by a very small number of ships, thereby casting an undue percentage of overhead costs upon the number of running trips conducted, Govern-

ment assistance will be essential for some years to come in order to establish this new method of communication, but I will deal with the Government contributions in another paragraph.

In the meantime, I simply desire to record the wonderful and tremendous opportunities that the successful establishment of such a means of communication will provide, and it must be borne in mind that no nation occupies the same favourable position as the British Empire for the establishment of an aerial service. Further, it is a fundamental necessity that quicker communications between the component parts of the Empire be established. Our Dominions are so placed that we need touch no foreign soil in establishing and maintaining our Airship Service, but, of course, there is no reason why we should not do so, and thus add the trading with foreign countries that will undoubtedly develop along our main routes.

Our first step must be Egypt, the country that eventually will be the Clapham Junction of our aerial services. Between London and Cairo it would be practicable to call at Marseilles and Athens, and there is no doubt the Governments of both France and Greece would be pleased to provide facilities for the call of British airships. These facilities would, in turn, provide the nucleus for subsidiary services from their immediate neighbourhoods, and such intermediary services would, in most cases, be supplied by aeroplanes. After arrival at Egypt, two extensions naturally follow, one to South Africa via Mombasa, and the other to Karachi or Bombay via Basra. The extension to Australia and New Zealand could follow from either of these termini (Karachi or South Africa), later developments determining the more suitable route. If from South Africa to Perth or Fremantle the vessel would invariably be helped by the recognised trade wind of this locality, but it is a big distance, and even with the help of the wind, entails a reduction in the commercial carrying capacity, owing to the extra quantity of fuel that would be required. At the same time, many airmen seem at present to favour this route because of its favourable winds, but it may be that, owing to commercial necessities, shorter termini distances may more than set off the favourable trade wind mentioned. Personally, I am in favour of the alternative route to Australia from Karachi via Colombo, Singapore and Java. From Java, the first Australian call would be in the vicinity of Perth. From that point either service would then follow on to Adelaide, Melbourne, Sydney and Wellington, returning by the same route. If, on the outward voyage from Egypt the Cape Town route was selected for Australia, it would be difficult to return this way, and it is more than likely that the Indian route would be selected for the return journey. Again, there is practically no trade from Africa to Australia, whereas there is trade between India and Australia, so that it would be quite possible on the Indian route to carry intermediate passengers and cargoes at proportionately higher rates, an undoubted attraction from the commercial point of view.

With a map of the world before you, and picking out the different points I have indicated, what a wonderful vista of commercial possibilities confronts us. The main routes would, in a very few years, be tapped at every point of call with subsidiary aeroplane and airship services. As to the personal advantages which such communications would give, they are almost without number. To-day, if we leave Tilbury for Melbourne by the fast P. & O. or Orient mail boats, it takes up 39 days from port to port. If, however, we travel overland and join the vessel at Marseilles or Toulon at this end of the voyage, and disembark at Fremantle, travelling by rail to Melbourne, we can reduce this to 34 days, but with an airship service, we could easily reduce it to ten days, even after allowing time for the vessels to moor and passengers to land for two or three hours at, say, half a dozen ports en route. Passengers would be entirely free from that present bugbear to so many of us against travelling, viz., sea sickness. The motion in an airship is entirely different from that in an aeroplane or steamer, there being, in fact, practically no motion whatever, and once you have overcome, as you do in a very short time, the feeling of vertigo when looking down, there is absolutely no sensation whatever. In the passenger car of the future aerial liner, one will sit at comfort without noise, vibration or motion, no dust or dirt as in a railway train, converse, write or play cards with perfect freedom, and from time to time, stretch one's legs from one end of the boat to the other. On the other hand

in aeroplanes, ordinary conversation and freedom of motion are impossible; consequently, on the question of the mental and personal comfort of a passenger, I doubt whether, with the present type of aeroplanes for long distance routes, it would be possible to average more than from eight to 10 hours flying per day. Whilst, therefore, the actual rate of flight in the air would be greater than airships, over a journey of a considerable length, it is more than likely that the airship would deliver the passenger in the shorter time. There is no difficulty, either, in the maintenance of an equitable temperature, so that we need not suffer the vicissitudes of extreme heat or extreme cold.

Then, can any one foresee the results of bringing Australia and New Zealand to within, say, 10 to 12 days of London? It makes possible, not only political conferences upon matters of vital importance to all portions of the Empire, but the commercial developments which closer association will undoubtedly bring in its train. Speak to-day to a big London business man or manufacturer, about possibilities in Australia, which could only be judged by his personal inspection. He looks at the time table and sees that even under the most favoured conditions, and only allowing a fortnight in Australia, it would take him about 82 days to accomplish the trip. With the establishment of airships he could make the same journey in 34 days. With such facilities there is no doubt but that there will be a very big expansion of British interests in all the Overseas Dominions. For a service of this description, too, mails are a necessity, and a working agreement between the Governments concerned would be essential so that the Airship Service could receive a sufficient and regular quota of mails for each vessel. The quick delivery of urgent goods would also stimulate trade between the far distant portions of the Empire. For instance, to bring in an individual note. What lady in Australia or New Zealand would mind spending, say, 30s. to 40s. in freight on a dress of the latest London model, instead of, as at present, being three to four months behind London fashions? Finally, the transfer of bullion and bankers' securities would mean a tremendous saving in interest, but none of these alluring possibilities can be brought into existence without the assistance and co-operation of the Governments concerned.

The whole position of airships boils itself down to one fact. At the present moment airships are practically controlled by military authorities, who have decided that as an offensive arm they are inferior to aeroplanes. Consequently, the sooner we get rid of airships the better this section of our military forces will be pleased. Such a view, however, entirely overlooks the Imperial character of an airship service, its immense benefit to the Navy, and its tremendous commercial possibilities. At the present moment, the military view of airships seems to be dominant, but it is inconceivable to me that the Imperial, Naval and commercial interests of this great country will permit a purely military opinion to sacrifice the possibilities which to so many of us are crying aloud for consideration and reasonable support. It may, perhaps, require a strong demand from the Overseas Dominions thoroughly to awaken Britishers to the danger which undoubtedly exists if the break up of plant and personnel is persisted in. That India, Australia, South Africa and New Zealand are fully alive to the potentialities of airships is, I think, clear, notwithstanding the fact that so few of the residents Overseas have had the personal opportunity of sighting or voyaging in existing airships. Mr. Hughes, the Prime Minister of Australia, has clearly indicated his belief and strong conviction, and his prompt action on his return to Australia is only what was to be expected from a man of his vision. Similar action by Africa, New Zealand and India will doubtless follow, but it should not take the combined demand of all these entities to overcome the lethargy undoubtedly existing in certain British Government circles regarding the undreamed of developments that will ensue from the successful initiation of a combined Imperial Service. The solution of the problem is for the Dominions to put up a definite proposition to Great Britain and ask the latter to join with them in helping ourselves to help each other.

APPENDIX.

The estimates are based on figures given by Lieut.-Colonel V. C. Richmond, in a paper read by him on October 17th, 1921, before the Royal Aeronautical Society, Scottish Branch. My calculations are, however, based in addition thereto on fortnightly services to

South Africa via Egypt and to Australasia via Egypt and India, utilising seven airships for such services, with reserves.

Capital Expenditure.

	£
Four new airships at £200,000 each	800,000
Refitting R36 and L71, say ..	50,000
Complete R37	25,000
Alterations at Cardington ..	30,000
Cairo Base—Removal and erection of existing air sheds with gas plant, mast, etc. ..	285,000
New Bases—Melbourne and South Africa, each £400,000	800,000
Mooring Mast Stations with masts and gas plants, etc.—9 at £47,600	428,400
Exclusive of Land and Working Capital—Total..	£2,418,400

Annual Expenditure.

Base.	Cardington £	Egypt. £
Maintenance of base ..	10,000	10,000
Electric light and power	3,000	3,000
Advertising and Office expenses	10,000	6,000
Personnel—wages and salaries	55,000	40,000
Transport	1,500	1,500
	£79,500	£60,500

Base.	South Africa.	Melbourne
Maintenance of base ..	10,000	10,000
Electric light and power	3,000	3,000
Advertising and Office Expenses	6,000	6,000
Personnel—wages and salaries	40,000	40,000
Transport	1,500	1,500
	£60,500	£60,500
Total		£261,000

	Per Station £
Mooring Masts—	
Maintenance	1,000
Electric light and power	1,500
Advertising and Office expenses	1,000
Personnel — Wages and salaries	7,000
Transport	1,000

Nine Stations each £11,500 = £103,500

Ships.

	£	£
Salaries of 7 crews (1 in reserve) each £12,000	84,000	
Petrol—2,500,000 gallons at 2/6	312,500	
Hydrogen — 300,000,000 cu. ft. at 10/- per 1,000 cu. ft.	150,000	
Food for crew and passengers at 7/- per head per day ..	26,000	
Material only for maintenance, labour being already included in the base personnel ..	80,000	
Administration, including London Office ..	40,000	
Depreciation—Buildings and Plant, say ..	55,000	
7 airships, 20 per cent.	280,000	
Insurance — Buildings, plant, etc., £2,200,000 at 10/- per cent. ..	11,000	
Airships — £1,400,000 at 10/- per cent., the company probably acting as their own underwriters ..	140,000	
	1,178,500	
Sundries and contingencies say	100,000	
		1,278,500
Total		£1,643,000

Revenue.

It is, of course, quite impossible to give reliable estimates of the revenue that will be actually received. One can only tabulate the sources of revenue and leave each individual to form his own idea of the proportion of each item likely to be secured both immediately and as the service successfully develops. The following schedule gives the yearly traffic in the selected items between Great Britain and South Africa, and India and Australasia.

	Passengers in and out	Rate of Steamer Fare £	1st Class Mail Matter in and out. Tons.	Present rate of Postage.	Parcel Post in and out tons.	Parcel Post Present Rates.
South Africa	15,329	97	355	2d. for first ounce, 1½d. each additional ounce	322	9d. per lb. up to 3lb., 1/9; 7lbs. 3/6: 11lbs. 4/9
India	26,223	90	485	ditto	573	ditto
Australasia	7,998	175	312	ditto	364	1/4 for first lb., 6d each additional lb.

Special Freights.

Articles.	Value.
South Africa.	
Diamonds, Furs, Feathers, Chemical Preparations, Drugs and Scientific Instruments.	£7,980,603
India.	
Furs, Chemical Preparations, Drugs and Scientific Instruments.	£1,586,601
Australasia.	
Furs, Chemical Preparations, Drugs and Scientific Instruments.	£1,615,434

GOLD.

In addition to the above there is also the transfer of gold from Africa and Australia to Great Britain and the re-transfer from Great Britain to India. Actual figures of gold transfers are difficult to secure, but it is estimated that bullion to the extent of £80,000,000 is annually transferred between these three centres each year. At present, it takes an average of 21 days between South Africa and England, 21 days between England and India and 42 days between England and Australia. There is no doubt that an average saving of at least 14 days would be achieved by airship transfer, so the saving in interest alone on £80,000,000 for 14 days at 5% amounts approximately to £153,425. Similarly bankers' negotiable documents could also be transferred with the same saving of time and consequent saving of interest. Assuming, therefore, that a fortnightly service with airships capable of providing lifting capacity of 20 tons for commercial purposes (passengers and freight) and calculating that each fortnightly trip on each service only averaged two-thirds of its commercial lifting capacity it would give the following result:—

Colony. 52 Trips per year, calculating 14 tons earning capacity, instead of the actual 20 tons available.

South Africa.	
40 Passengers and baggage= 6½ tons=2,080 Passengers at £100 each.	£208,000
Mail matter—2 tons=104 tons at 9d. per oz.	£139,776
Special Freight 6 tons, say 300 tons at 10/- lb.	£336,000
India and Australasia.	
50 Passengers and baggage= 8½ tons = 2,600 passengers at £100 per head for India and £200 for Australasia. Proportionate for intermediate.	£520,000
Mail Matter — 4 tons — 208 tons at 9d. per oz. for India and 1/- oz. for Australia, calculated at 1/- per oz.	£372,736
Special Freight — 2 tons = 104 tons at 12/- per lb.	£139,776

The total Revenue may, therefore, be summarised as follows:—

Passengers	..	£728,000
Mail Matter	..	512,512
Special Cargo	..	475,776
		£1,716,288

Subsidy required from Great Britain ..	250,000
Subsidy required from Overseas Dominions	250,000
Estimated Revenue	£2,216,288

DISCUSSION.

MR. M. L. SHEPHERD (Acting High Commissioner for Australia) in opening the discussion, thoroughly endorsed Mr. Ashbolt's remarks with regard to the efforts of Mr. Hughes, and assured the audience that Australia was intensely interested in any scheme of the kind which would bring her closer to the heart of the Empire. The present condition of affairs, in which Australia was between 30 and 40 days away by mail, was one which the Commonwealth looked upon with very great dissatisfaction. As an instance of Australia's bona fides, Mr. Shepherd mentioned that Mr Hughes, immediately on his return to Australia, put the matter before Parliament, and it had been referred to again during the last few days, when Mr. Hughes again confirmed his intention of going on with the scheme if the British Government was prepared to do so. Mail services with flying machines had already been started between certain points in Australia, and many more were under consideration. Meanwhile, the preparation of landing grounds and the necessary accommodation for flying-machine services between various capitals in Australia was being rapidly proceeded with. It would be seen, therefore, that Australia was intensely interested, and in earnest in regard to aviation.

CAPTAIN SIR ROSS MACPHERSON SMITH, K.B.E., M.C., D.F.C., A.F.C., remarked that he had not had practical experience of airships himself, but he had watched their progress for some time, and had also talked with various experts of the airship branch of the Service; and the conclusion he had come to was that the airship of the present time was a perfectly sound means of transport. The present was an age of rapid transport, and anything which could carry from one place to another more quickly than at present was a great boon for the whole community. He had often been asked his opinion of an aeroplane service between Great Britain and Australia. He had always maintained that an aeroplane, if looked after properly and treated in the way it should be treated, would fly anywhere; but he understood that the machines flying between England and Paris at the present time had an economic range of 500 to 600 miles, which meant that if those machines started to fly to Australia the flight would have to be done in relays of between 500 and 600 miles, and with relays of aeroplanes. That would mean that a passenger would have to land every five or six hours, which would be a big strain. He thought the solution of the whole difficulty was to use airships for long-distance work and to use aeroplanes to feed them, the latter concentrating on the points at which the airships landed, thus having the two services working together. He sincerely trusted that Mr. Ashbolt's scheme would have the success and the support which it so richly deserved.

LIEUT.-COLONEL V. C. RICHMOND (Air Ministry) thought all were agreed that Mr. Ashbolt, in his paper, and also in his various other activities to promote an airship service to the Dominions and India, had done pioneer work for which he deserved the utmost appreciation and thanks. There could be no doubt whatever that the British Empire was the soundest and most profitable ground for the development of enterprises of air transport, being unique, as it was, in possessing routes over which there was everything to gain by such means of transport The necessity, both political and economic, for bringing the Colonies into closer touch with the motherland had been emphasised at the recent meeting of the Dominion Premiers in London; and seeing how great was the necessity of such communication, it was quite natural for thinking men to ask themselves how that was to be brought about. To build a steamship which would have a speed of anything approaching 50 miles an hour was almost a technical impossibility, and the cost of building a fast steamship was so enormous as to require a subsidy out of all proportion to that which airships would want to do the same service. The question, therefore, seemed to be whether an airship service was technically possible, and if so, whether it could be made self-supporting at the start, or, if not, whether it was worth subsidising. The recent Committee had not questioned in any way the practicability of airships from a technical point of view. Within a short time enormous strides had been made, and most revolutionary developments were in sight. These were most unfortunately held up for the present, but as soon as there was an incentive to go on, he felt sure that those developments would be brought to fruition. It was obvious that an Imperial airship service could not pay its way at the outset; there would be the big capital cost of the bases and the educating of the public to the immense advantages of that means of transport. As far as the final benefit of the service was concerned, speaking as a technical man, he might say that if the airship could fly to India at all it would reach India in five days. There was no need to enlarge on this statement. The audience could be safely left to judge the immense benefits which

would be gained from this single item alone. The urgent need for quicker communication must be met. His Majesty the King, in his address to the Dominion Premiers when they left the country, issued a call to the men of science to find some means of producing more rapid communication with the Colonies. He (Col. Richmond) would humbly suggest that one of the many benefits derived from the terrible scourge of the late war was that men of science had already produced such an instrument in the airship which was capable of carrying out His Majesty's hopes and wishes.

MAJOR-GENERAL SIR WILLIAM S. BRANCKER, K.C.B., A.F.C., congratulated aviation on having obtained, from outside itself for a change, such an able champion as Mr Ashbolt. As a rule, most people connected with aviation were looked upon merely as amiable enthusiasts not to be listened to very seriously. Mr. Holt Thomas, who was at the International Air Conference in Paris, had asked him to place before the meeting his views on the question of the airship. Mr. Holt Thomas firmly believed in airships for commerce, and that speed was the greatest boon which aviation was going to give to commerce He was rather averse from plunging at once into a definite airship service round the world until further data had been obtained, and he was under the impression that the present 60-miles-an-hour airship was not fast enough for the long routes which Mr. Ashbolt had mentioned, unless, after meteorological reconnaissance, it was found that in going backwards and forwards to Australia winds were available to help both ways by following definite routes. Personally he (Sir William Brancker) thought it was quite possible that the best route to Australia would be via Africa, and that the best route back from Australia would be via South America. Mr. Holt Thomas felt that the Government should certainly go on with airships, that, even in their present condition, they were a very efficient Naval weapon for reconnaissance, and that experiments on long air routes should certainly be continued. He considered that the mooring mast was the greatest development in commercial air work that had been brought about in recent times.

Turning to his own views, Sir William Brancker said he was usually called an aeroplane man, and was supposed to be biased on the side of aeroplanes ; but, actually, he was not He was very keen indeed on airships and their development. He considered that it was an absolute scandal that the Government should have ceased to continue experimenting with them, and to have reduced the development of airships to its present really futile and hopeless condition. A non-inflammable gas would turn an airship into a dangerous military weapon to-morrow, and a little more development in the size and speed would make it a great commercial asset. He went further than Mr Holt Thomas, who said that the only boon that aviation would give to commerce was speed. The airship would give also comfort. He would far sooner travel by airship than by steamer. Taking Mr. Ashbolt's figures, the airship would give economy. Those figures, moreover, made him think that a subsidy was hardly necessary. Mr. Ashbolt quoted a fare of £100 to India or South Africa. He thought quite a sufficient number of passengers would be found who would be willing to pay £200, and in that case that would leave very little to be supplied in the way of subsidy. The Government attitude towards aerial transport was, "What is the good of it unless it is going to pay ?" He said it could pay, and would pay to-morrow if the Government would give a guarantee of a really large load of mails. But even if an airship service was not going to pay, why should it be of no use ? The telephone service did not pay, but nobody would like to be without it The railway and telegraphic services in Central Africa or in the undeveloped parts of India had not paid at once. It was not proposed to stop all railway and wireless and telephonic development because those services did not pay in the first instance. But aviation could and would pay if it was properly assisted and run He thought it was time for one of the leading shipping companies to work out a plan for the future running of their ships at 12 or 14 knots, instead of the present high speed, and of running in conjunction with those slower-speed ships an airship service at 60 miles an hour. They could carry the mails, and the rich passengers could afford to pay for speed, in the airships, and the ordinary passengers could plod along at 14 knots at considerably lower rates than they were paying at present. The cost of shipping to-day was largely due to the high speed demanded, and if the shipping companies were prepared to cut that high speed for the ordinary average individual and put the savings into an airship service, a more practical and economical situation would result Mr. Ashbolt had said that the Air Ministry was necessarily dominated almost entirely by military influence. Why "necessarily ?" When Lord Weir left the Air Ministry he left a great heritage. He had been a firm believer in aerial transport, and there would have been no military influence if he had continued there. Aerial transport had been severely and definitely let down by the Government policy of 1919-20, and now, even with the best of intentions, it was very hard indeed for the Air Ministry to recover that lost ground, firstly, because the financial situation was extremely bad, and, secondly because the name of aviation had been blackened in the eyes of the Treasury, who would not now be persuaded into spending money on it He

believed absolutely in the airship. The aeroplane and the airship could work perfectly amicably side by side. They were not rivals; they were firm allies. This wonderful Empire of ours was spread out all over the world. Its one cry was for closer communication, and aviation was the one thing that could give it that, and if we did not get it, either we or our children would repent most bitterly. Therefore it was up to the British public to continue agitating until the Government did apply foresight and common sense and proper economy to the development of both the aeroplane and the airship.

Constructor Commander H. B. Wyn Evans, M.B.E., M.I.N.A. (Royal Corps of Naval Constructors), said that as one who had been intimately connected with the design and construction of rigid airships since 1915, and who had taken part in a considerable number of flights in most types of aircraft, and hence realised their respective limitations, he felt sure he should be excused for wishing to make a few remarks. Mr. Ashbolt was to be congratulated on his great paper. He deserved the thanks, not only of those who believed in airships, but of all British peoples. He had first met Mr. Ashbolt when he visited the Royal Airship Works at Cardington a short time ago, and travelled back to London in his company. That greatest of airship enthusiasts and finest of officers, the late Air Commodore Maitland, was with them, and also Squadron Leader Colmore. Two remarks made by Mr. Ashbolt in that Midland Railway saloon over a cup of tea had impressed themselves on his (the speaker's) memory. One reply to the query of Air Commodore Maitland's was: "I do not offer alternatives; they cause delay." The other was: "I do not explain; explanations cause delay." Mr. Ashbolt, of course, intimated that he was sure of his facts, and that in both of the above cases he was dealing with a Government Committee.

If those two quotations were any indication, then Mr. Ashbolt was a man who would help to keep the British Empire together and ahead of the rest of the world by and in airship work. He was, in fact, a worthy successor to the late Air Commodore Maitland in the work of spreading the airship faith. In a paper by Air Commodore Maitland, read in that hall last year, he said :—

"A question of great practical importance in the preliminary consideration of airships is the interchangeability between the service and the commercial airship. The airship, although already developed to the stage of great utility both for service and commercial purposes, is not yet highly specialised, and its rapid conversion from one use to the other is a matter of comparative ease. The hull in both types will, for many years to come, be the same, and it is, broadly speaking, merely a matter of replacing the commercial accommodation with bombs, machine-guns, etc., to convert the commercial rigid into a most efficient service airship. This interchangeability is far more marked than in sea-going vessels. The air-ship of to-day, so far as its adaptability is concerned, should be compared to the sailing vessel of Elizabethan time, ready at her country's need to become a ship of war and capable of as rapid conversion. This question of the interchangeability of the service and commercial airship is of extreme importance, as on it depends the logical and economical method of future development.

"The close association between the Navy proper and the mercantile marine has been proved beyond question an unqualified success in the Great War. The required number of surplus air personnel not required in peace, but of vital necessity in the event of war, can be kept economically in training by the existence of a commercial airship service. Economy will be essential in all matters for many years to come, and I hope I have made it quite clear that the necessary reserve of airships and personnel to meet the exigencies of war can be economically provided by a commercial airship fleet."

Mr. Ashbolt had ably dealt with the value of airships to the Navy. Mr. Rudyard Kipling had uttered the following words in Paris a day or so ago: "What our politicians do not sufficiently understand is that there are scattered throughout the whole of Europe, possibly throughout the whole world, fathers of families like myself who have lost sons in this war, and whose one common cry is 'Security.'" Britain could provide that security if she became as supreme in the air as she was on the sea, but not unless. They had the brains, the men and the money (if less were wasted). They only wanted someone with the courage to say, "Go ahead." He might be permitted to say a word or two regarding R38. On behalf of the Design Staff at Cardington he begged to offer grateful thanks to Mr. Ashbolt for the report of his last conversation with their late revered chief, Mr Campbell. He did not think any one other than themselves who were in daily touch with Mr. Campbell would ever realise how his every thought during the last few years had been of and for airships. His faith in them had been supreme, and the continual "set-backs" had been very severe blows to him, as to all. More full scale experiments had been required, and that was what was wanted to-day, and they should be the first things to be put in hand, and at once. R 38 had been essentially a service ship, and designed during the war, and great things had been demanded, and, he believed, could have been realised. She did altogether about 50 hours actual flying, and had completed over 30 hours in the air on her last flight before the tragic accident happened. With airships designed and built for commercial purposes, fine margins would not be necessary. Ships of a more robust nature would be designed—ships that could withstand all weathers and be able to live at the mast almost indefinitely. The public must be impressed with the fact that the experimental days were over. Experiments and research were, of course, necessary for improvements, as in all vehicles for transport, but an airship could be built to-day that would successfully and repeatedly accomplish the return journey to America or a journey to the Antipodes. If the German-Spanish plans matured before we got to work, they would capture all the airship traffic on terms with which we could not compete, and the nation with commercial airships and flying experience

at her disposal was the nation with the future of the air in her hands, whether it be in times of peace or the agony of war. They who believed in airships would wish for an all-powerful body to govern development on behalf of the British Empire An airship structurally sound had little or no danger from hydrogen and could, he believed, be made immune from petrol fire. Experience of over two million miles flown during the war and since was evidence of that When heavy oil engines were introduced those dangers would disappear altogether. The late Flight-Lieut. Pritchard, in the discussion on his (the speaker's) paper read before the Institution of Naval Architects last year, said: "I would like to emphasise, in conclusion, the importance of improving detailed design which will ensure reliability of service with existing ships, rather than proceeding with costly new construction of large rigids of greater performance on paper. Even if the limitations imposed by the present financial situation did not exist, I would still urge the soundness of the policy of perfecting existing ships in the few vital respects which are alone necessary to make the airship of to-day truly commercial." Those of them who realised Pritchard's genius would remember his words, and hope to have the opportunity of acting on his advice and that of those who went with him, thereby in a small way perhaps doing them honour in gaining, for the British Empire, that great asset, and for the world, Security.

THE CHAIRMAN (Lord Montagu of Beaulieu) said that, having studied the subject from the Indian point of view, possibly more than from any other standpoint, he thought it would be of immense advantage to India if she could get into closer touch with Europe and especially with this country. At the present moment, by the fastest route via Marseilles, and by the best mail ships, it took 16 days to reach Bombay, the sea route being 6,000 miles. By going via Cairo and Basra, the distance was shortened to something like 4,500 miles. At 100 miles an hour, that would mean only a 45 hour journey, but even if it were a 90 hour journey, it would mean a saving of ten days The greatest interest was being taken in the subject in India. When he read a paper not less than five years ago on the matter, he had foreshadowed a service to India. Such a service had since really come about. There had been not only direct flights to India, but there had been flights over intermediate distances towards India. He hoped that in the future, India, as well as other important parts of the Empire would have a regular airship service. He welcomed Mr. Ashbolt as one of the most able recruits to aviation who had come forward in recent times.

LORD MONTAGU OF BEAULIEU then vacated the chair, which was taken by SIR CHARLES S. BAYLEY, G.C.I.E., K.C.S.I

COMMANDER SIR TREVOR DAWSON, BT., R.N., remarked that we lived to-day in extraordinary times. We still saw great armies in being on the Continent; two great Powers were still building ships and launching them, and the great British Empire at the present time had not a single ship under construction and had actually stopped even the preliminary work on four cruisers urgently needed to replace obsolete vessels. We were practically doing nothing at all with regard to the development of armaments generally for the defence of the Empire. It was a very extraordinary position; yet, having regard to the economic situation to-day, it was not a matter of surprise that the Government could not afford money for the development of the airship. He would like to add his opinion, for what it was worth, that he did not think any Fleet to-day was complete without airships and aeroplanes. That being the case and our Navy being all-important to the Empire, was it not, from the economic standpoint, the duty of the great transport companies and patriotic members of the Empire to get together and to develop the airship for commercial purposes so that such practical experience could be used by the Army and Navy, especially as they all knew that such experience was absolutely essential? That was really the point he would like to make. It was impossible to-day, in the present state of the finances of the Empire generally, to spend a lot of money, but was it not the duty of the citizens of the Empire to get together and take the matter up? There was no doubt whatever that our great engineers—mechanical, aerodynamic and others—were more than fitted to do everything that any other country might do, and we should not allow other countries to get in front of us. Our structural material and principles of design, our internal combustion engines, gas bags and other components were of the very best. It was really up to the people of the country to find the necessary money in order to organise a proper transport service so that the Navy and the Army could have full advantage of it in times of emergency.

MR. ALFRED BIGLAND, M.P., in proposing a vote of thanks to Mr. Ashbolt, said he did so in a public capacity, in that he was the Chairman of the Empire Development Parliamentary Committee. The audience would be glad to know that during the last few months a desire had grown up in the House of Commons to do all they could to enhance the development of the Empire in every direction. Before hearing the author's paper, he had been an ignoramus almost on aviation, and its possi-

bilities with regard to speed and cost. He had been intensely interested in hearing the paper, and he would take it with him to his Committee. It might surprise many to know that that Committee had grown so fast that at the present time it numbered 208 Members of Parliament. As Chairman, he had felt it was quite impossible to work a Committee of that size in a business-like way, and, therefore, it had been divided up into Committees of 15 or 20 members, each dealing with a different subject. One of those Committees was going to devote itself to that branch of empire development work dealt with in the paper, and perhaps Mr. Ashbolt would do the Committee the favour some day of talking to them in a Committee Room of the House of Commons, so that when aviation estimates came before the House, the Members might really know something more than they had been able to acquire up to the present time. The idea he had in mind was that the Empire was in the position of every other nation in the world to-day, namely, it must protect itself, it must grow within its own borders all that it needed, and that it must employ its own people in its own industries to an extent which had never been known before. The subject dealt with in the paper would be one of the most important ways of bringing the Empire together as a unit. Although he felt that the House of Commons could not pass estimates for big sums for the development of civil and military aviation at the present moment, yet the study of the matter would, he hoped, prepare them within a few years, when the finances of the world became a little more normal, to face such estimates.

MR. PERCY HURD, M.P., in seconding the motion, said if ever there was a subject which should interest the members of the British Empire it was aviation. Mr. H. G. Wells had said the other day that the British Empire could not last for very long. It certainly could only carry out its great purpose if there was a better understanding and a closer sympathy between all parts of it. On that point might he utter a word of warning, as a Member of Parliament? He appealed to everybody in the matter of airships and aircraft development, to think less of subsidies and more of self-help. Officialism had gone far to paralyse our Empire wireless developments by red tape and other obstacles, and in the matter of the development of aircraft, which was essential to the Empire, he asked the public to think less of Government Departments and to rely more on the genius of the British people for self-management and self control.

The vote of thanks was carried unanimously.

MR. ASHBOLT, in reply, said that when it was suggested to him that he should prepare the paper, he felt that it had been a very great compliment not only to himself, but to the State of Tasmania, which he had the honour of representing at this end of the world. If he had helped the British public to realise the possibilities of an Imperial Air Service, then he had been amply repaid for the little work he had done. He personally realised the opportunity for getting the Empire closer together, and he also realised the danger which must attach to our negligence if that opportunity were not taken.

With regard to Sir William Brancker's remarks, the estimates certainly showed that the possible revenue pretty closely approximated to the possible expenditure, but before that possible revenue could be obtained, some little time would have to elapse, and during that educationary period, the assistance of the Governments was absolutely essential. After five or six years, he believed it was quite possible that the business could be self-supporting, but in that intermediary period which required such a big amount of overhead capital expenditure, some revenue must be guaranteed to justify the provision of that capital under the present stringent conditions. He was not a believer in charging maximum fares. His experience as a business man was that if one was going to get whole-hearted support one should charge—whether it be for food products or means of communication—at approximately the same rate as existing conditions. The big bulk of the people were not prepared to pay high rates for an accelerated service. If one gave them an accelerated service at approximately the same rate, one could then command their trade; and it was with the idea of commanding trade and getting the thing on a commercial basis that he had suggested reasonable fares and not maximum rates. In conclusion he desired to thank the Royal Society of Arts for the opportunity it had afforded him to read the paper, and also Lord Montagu of Beaulieu for taking the chair.

The proceedings then terminated.

PRUNE GROWING IN SOUTH-WEST BEDFORDSHIRE.

Mr. N. J. Wood, in an article in the December number of the *Journal of the Ministry of Agriculture*, gives the following account of Prune-Growing in South-West Bedfordshire:—

The prune-growing district in South-West Bedfordshire and in North Buckinghamshire, occupies a belt of land about 14 miles long and 2 miles broad stretching from Stanbridge and

Totternhoe in the east to Aylesbury and Wendover in the west. There are some 2,000 acres of fruit in the whole district, and in the smaller area in Bedfordshire and on the borders of the two counties about 500 acres are under prunes.

In the smaller area the soil is a fairly heavy clay, mixed with which is a large percentage of lime. This soil appears to suit the prune, and the need for lime is shown by the fact that in one orchard where prunes were planted on clay no success was obtained until the soil had been heavily limed, after which the trees made excellent growth. Many growers apply lime, which is conveniently obtained from the numerous lime-works near Dunstable. The under rock is almost pure limestone, which on the Dunstable Downs often comes to the surface.

Cultivation.—The prune orchards are all under grass and do not come into full bearing until the trees are about 30 years old. Most of the orchards were planted about 40 or 50 years ago, and are therefore now in their prime; it is said that the trees will continue bearing fruit until they are 100 years old. After planting no cultivation of the soil takes place; it is found that cultivation prevents fruiting, and once the tree is formed the orchards are allowed to run to grass and are used as poultry runs, or, later, as keep for cattle and pigs Cow manure appears to be very beneficial to the trees.

In many of the smaller orchards the trees were planted un-systematically and little attention was paid to them in their early stages, so that they are now badly-shaped and weak-bearing. Where planted systematically, however, it has been found that the trees must be given plenty of room owing to their spreading habit and the size they attain. Thirty feet square is not too much if the trees are to have full advantage of light and air The weak spreading habit of the tree often causes the branches to bend down to the ground with an abundant yield of fruit. Some growers have permanent props for the principal branches, and these undoubtedly prevent damage to the fruit.

Once the tree is formed no pruning is done except to cut ont dead wood. Even this is often neglected, with the result that in many cases large main branches have had to be removed eventually, whereas a little judicious cutting a few seasons before would have prevented the spread of the diseased wood.

As a rule, manuring is confined to the droppings of animals, but some growers apply farmyard manure or shoddy as a mulch round the trees; and as stated above a dressing of lime is often given.

Character of Tree.—The prune tree is always grown as a standard in this district and attains considerable size. The leaf is smaller than the ordinary plum leaf but larger than that of the damson. The fruit is very similar to the damson, but much larger, and a very fine "bloom" is a characteristic which distinguishes it in normal seasons. In taste it is bitter, but its keeping qualities are excellent, and for this reason a large quantity of the fruit is dispatched for use in the Fleet. This appears to be one of its chief uses; another is that of making dyes for silken materials. So far as can be ascertained it is not used as a dessert fruit, but is largely used for culinary purposes, and owing to its lateness usually commands a good price.

Marketing.—A considerable quantity of the fruit goes to the markets in the great northern towns, but consignments are sent to all parts of the country. This season has been a very bad one: though the trees blossomed well, frost did a lot of damage before the fruit set, with the result that the crop has been practically a failure. A good season has not been experienced since 1918, when an average of about 5 tons to the acre was obtained; in 1919 about half this quantity was picked, but last year and this year only a few bushels have been gathered. A normal season yields 4-5 tons to the acre. The fruit is usually sent away in sieves and half-sieves, and as a general rule travels very well.

It is astonishing that this fine prune has not spread to other districts. There is a local belief that it does not grow well in Kent, but in all probability it has never had a fair trial. A certain number of suckers were sent to Wisbech and up to the present they are giving indications that they will do well, although their exploitable age has not been reached.

Pests.—The chief insect pest is the leaf-curling aphis which does very considerable damage in some years, a reduction of 20 per cent. in the crop resulting. Caterpillars of the lackey moth are sometimes troublesome, and a mite, which causes galls upon the leaves and renders them unsightly, is sometimes found in the older orchards, but the damage done is not sufficient to result in appreciable loss of crop.

Silver Leaf has appeared in some orchards, but few trees have been killed or have had to be totally removed. The reason for this apparent resistance is probably the vigorous growth and natural hardiness of the prune; and the possible use of the prune as a stock for other plums, especially Victorias, is suggested as a method of combating the disease.

Very little spraying is done in the district, except in the best orchards. A home-made mixture containing copper sulphate and lead arsenate has proved very satisfactory. Some growers limewash their trees and occasionally spray with lime, but as a general rule, owing to the expense of the operation, the small orchards receive little or no treatment.

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FRIDAY, DECEMBER 30, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 4, at 3 p.m. (Juvenile Lecture.) WILLIAM REGINALD ORMANDY, D.Sc., F.I.C., "Clay: What it is—Where it comes from—and What can be done with it." The lecture will be illustrated with experiments.

Special tickets are required for this lecture, and no person can be admitted without one. A few tickets are still left, and these will be issued to Fellows who apply for them at once.

DOMINIONS AND COLONIES SECTION.

The Council have appointed Mr. P. J. Hannon, M.P., Director of the British Commonwealth Union, a member of the Dominions and Colonies Committee.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

CASES FOR JOURNALS

Cases for keeping the current numbers of the *Journal* are now obtainable. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s*. 6*d*. each, on application to the Secretary.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

WEDNESDAY, NOVEMBER 30TH, 1921.

SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works and Public Buildings, in the chair.

THE CHAIRMAN, in introducing Mr. Noel Heaton, the author of the paper to be read, said he thought everyone present was aware that Mr. Heaton was a very well-known technologist and chemist, thoroughly familiar with the problems which had to be dealt with in the preservation of stone Personally, he was very interested in the fact that Mr. Heaton had paid a considerable amount of attention to the subject of glass technology, and he hoped that some day he would enlighten the Fellows of the Society upon that question He felt the author was a man of entirely unbiassed views and of scientific training, and that those present could rely with complete confidence upon his giving them a very clear, unbiassed and scientific view of the very difficult question with which the paper dealt. Mr Heaton had written many admirable treatises on colours, oils and varnishes, and personally he had been enlightened in many ways by the admirable documents Mr. Heaton had published. He thought the subject of the paper was one of primary importance at the present time. There was not the slightest doubt that it had been one of increasing urgency since the nineteenth century, and when the character of the alteration in the London atmosphere in modern times, since the industrial revolution, was realised, it would be seen that the problem was going to become more urgent rather than less. He made a calculation before Lord Newton's Committee on Smoke Abatement—and he believed his figures were accepted—that there were thrown into the London atmosphere per annum, roughly 80,000 tons of sulphuric acid, and it was surprising that the stones used in London buildings could stand up at all under the conditions to-day. He had tried to ascertain whether the question of stone preservation was referred to in any mediæval or classical documents. He could find very few instances, though there were references in certain mediæval

documents showing that attempts were sometimes made then to preserve stone by oiling it, but there was no record as to the effect of that treatment. Perhaps Mr. Heaton could say what the effect of it would be. He also found that Sir Henry Rawlinson claimed to have seen a very early cuneiform inscription which he thought had been treated with some solution of silica, but it was contended afterwards that that might have been merely due to the fact that water containing silica had passed over the inscription. It was very important that a decision should soon be arrived at as to whether there was a solution to be found, and it would be a solid gain, even if it could be definitely ascertained that there was no solution, because the attention of those interested in the subject could then be turned to other matters, such as the question of the pollution of the London atmosphere and the atmosphere of other great urban areas by the distribution of sulphuric acid through coal being used as a raw material.

The paper read was :—

THE PRESERVATION OF STONE.

By Noel Heaton, B.Sc.

The preservation of building stones is, by common consent, one of the most baffling, and, therefore, one of the most fascinating problems with which the technical chemist is faced. In bringing the subject up for discussion once more to-night, let me say frankly at the outset that I am not coming forward with any claim to have solved the problem, and to offer architects a sure and certain process for preventing and arresting decay. There are many, both amongst architects, geologists and chemists who consider that the problem is definitely insoluble, and any attempt to solve it is a waste of time. Whilst I am not so pessimistic, the more experience I gain on the matter, the more I realise the difficulties in the way of a really successful solution. It can only be accomplished by the united efforts of all concerned in the maintenance of our public buildings, and by constant exchange of experiences.

There is no need for me to enlarge upon the importance of the quest. It must be patent to everyone that hundreds of thousands of pounds are spent annually in keeping the stonework of our buildings even safe, and that, in spite of every care, our historic buildings are crumbling away. For many years past architects have been bombarded with a succession of patented or secret proprietary processes, each claiming to be the long sought panacea, but each in turn proving of very indifferent value.

The problem is not one that should be left to private enterprise : the discovery of an efficient method of preservation is a matter of national importance and can only be dealt with on a national basis. H.M. Office of Works has fully recognised this, and has had the matter under constant observation and investigation for years. Every process that has been introduced has been given full and impartial trial, and extensive investigations have been made under their direction by Professor Church, and since 1914 by Professor Laurie. Recently, the Department of Scientific and Industrial Research has undertaken investigations, more particularly in connection with the protection of new stonework.

As yet, no comprehensive account of the results of these investigations has been published, and in the absence of such detailed information, the architect entrusted with the preservation of buildings may well be in doubt as to what course to pursue. My purpose, therefore, is not so much to propound any new theories as to survey in a concise form the present state of our knowledge of the subject, and present for criticism and discussion, my views as to what can and what cannot be done, in the hope that it may be of some little practical service.

Let us glance for a moment at the fundamental conditions of the problem. Confining the issue to natural building stones, the geological formations from which these are obtained fall into two main groups, the hard crystalline igneous rocks, such as granite, and the sedimentary rocks, which, according to the conditions under which they were deposited, range from a pure limestone, such as chalk, consisting almost entirely of calcium carbonate, to a stone consisting entirely of grains of sand cemented together by silica and containing practically no lime. Between these two extremes we have every possible variation of chemical composition and physical and petrological structure. Not to attempt a detailed description of the large range of building stones thus available, which would land me into a paper on Economic Geology rather than Stone Preservation, the following rough and ready classification of the main types of sedimentary rocks based on chemical composition is sufficient for our purpose :—

	Aggregate.	Cementing material	Example.
Limestone	Calcium carbonate.	Calcite	Portland, Bath
Magnesian Limestone	Calcium and magnesium carbonate.	Calcite	Anston.
Siliceous limestone	Calcium carbonate and silica.	Calcite	Chilmark.
Sandstone	Crystalline silica and silicates.	1. Calcite	Reigate.
		2. Iron and calcite.	Red Mansfield.
		3. Hydrated silica.	Craigleith.

Leaving out of account variations in physical structure which are at least as important as chemical composition, broadly speaking the harder and more siliceous a stone is and the less lime it contains, the more durable it is. One can generalise the order of durability as :

1. Granite.
2. Siliceous sandstone.
3. Magnesium limestone
4. Limestone.
5. Calcareous sandstone.
6. Ferruginous sandstone.

If durability were the sole consideration in selecting building stones, one might use nothing but hard igneous stones like a fine grained porphyry or granite, and decay, although it would still exist, would become a minor problem. Unfortunately, there are *many* other things to be considered. The harder a stone is the more difficult it is to quarry, and, therefore, the more expensive it is. But even apart from any question of economy, it is impracticable to use a hard crystalline or siliceous stone, except in buildings of a severe elevation, on account of the difficulty of carving anything in the nature of complicated enrichment. For the elaborate carving characteristic, for example, of mediæval cathedrals, a freestone is essential. Taking these and other practical considerations into account, granite, and even the hardest sedimentary rocks, such as millstone grit and Craigleith, can only be used in a limited degree, and the great majority of stone buildings of to-day—and a still greater proportion of mediæval buildings—are constructed either of limestone or sandstone, the particular quality used depending on the locality and the limitations as regards transport.

The question of decay and its prevention, therefore, largely centres round those particular types of stone.

So far, I have referred to the matter as one of preventing decay in new stonework, but there is another and still more difficult problem involved. It is with this wider aspect, that of preserving and maintaining the fabric of buildings already suffering from decay with which I have been more particularly concerned. You will notice that I do not specify ancient buildings in this connection, because it is on record that many modern buildings have suffered badly from the ravages of decay. It is on record, for instance, that the condition of the Houses of Parliament was such as to cause serious alarm within twenty years of their erection, notwithstanding that at the time of building the selection of the stone, and method of construction, was made the subject of most exhaustive enquiry.

Let us enquire briefly into the causes of this decay. The disintegration of building stone arises from several distinct causes which may operate simultaneously, each increasing the effect of the other. In the first place, there is the *natural* disintegration, which takes place in all rocks on prolonged exposure to ordinary conditions of country atmosphere. The effect of rain on a sound homogeneous stone is to produce a surface weathering which adds to its beauty, but in highly absorbent stones of uneven texture absorption of moisture combined with subsequent frost, causes disastrous flaking. Violent fluctuations of temperature result in minute cracks where the stone is composed of minerals which vary in expansion. Wind causes considerable disintegration, more particularly in sandstones, by mechanical erosion. Along the coast the effect is more rapid, owing to the presence of alkaline salts. Disintegration is also caused by direct oxidation in the case of ferruginous sandstones, the iron salts which form the cement oxidising and losing their binding power, so that the stone

crumbles. This is particularly the case with some stones containing sulphur compounds, such as *marcasite*, which oxidises to form soluble salts.

The effect of these natural agencies is accelerated by irregularity of structure, such as bands of varying hardness, which cause flaking by uneven absorption of water. Still more disastrous is the irregularity of structure caused by invisible cleavage planes caused by diagonal pressure in the original rock, due to earth movements. A well known case of this is the Anston stone used in the Houses of Parliament. This stone was at one time traversed by minute fissures running at an angle of about 60° to the natural bed. These cracks have been subsequently cemented up by infiltration, and are quite invisible in the quarried stone, but they form planes through which water can more readily percolate. The result is that, sooner or later, the stone splits along the line of weakness and comes away bodily.

There are cases, again, in which stones differ in durability for reasons which are, at present, obscure. The difference between Bath and Portland stone is an example. The chemical composition is almost identical, both are oolitic in character, and there is little difference in structure to account for the notorious difference in durability. We have, in fact, still much to learn as to the influence of minute differences of physical structure in natural building stones. It has been suggested* that the presence of a small percentage of soluble salts in the original stone may influence its durability, and careful research on points like this may throw much light on the problem of preservation.

The growth of vegetation on stones is another peculiar point—some stones are affected in this way more than others, for no apparent reason. The growth of vegetation in most cases accelerates decay, particularly when it takes the form of mushroom like patches, which act like a sponge, keeping the surface damp. The development of lichen on stones, is, however, in many cases actually beneficial. Those minute lichens which one finds covering old buildings with flat, closely adherent plates, I regard as a natural preservative. They tend to shed rather than absorb water, and they certainly act as a buffer to the erosive action of the wind. It is

*A. Lucas.—"Disintegration and Preservation of Building Stones in Egypt."

fortunate that one can regard them in this light, as I think everyone will agree that they enhance the beauty of the stone in a way that no art can achieve. The action of micro-organisms has been suggested* as playing a part in the decay of stone, but whilst this is a possible contributory cause, I do not consider myself that it is a primary one, the organisms being present rather as a result of decay than causing it.

I pass from the natural to the *unnatural* causes of decay; using this term in the same sense that you speak of a man leading an unnatural life who spends his time in the close confines of an unhealthy slum. It is unnatural for a building to suffer the ravages of that peculiar product of modern civilisation, the urban atmosphere, which is essentially an extreme dilute solution of sulphuric and sulphurous acids.

The action of sulphuric acid, coupled with the accumulation of soot and grime, is the most potent cause of decay at the present time, although we can safely say that we have passed through the worst, and may look towards the future with a certain measure of hope. There is still another contributory cause to decay, which I will call faulty construction. For instance, it has been an axiom in building from time immemorial that a stone should always be laid in its natural bed, for reasons which a rudimentary knowledge of geology renders obvious; ignoring this axiom by "face bedding" the stone increases the rate of decay enormously The use of iron dowels and cramps is another well recognised cause of splitting and flaking of stonework, owing to the strain set up by the rusting of the iron.

I now show you a few typical examples illustrating the effect of these various destructive agencies, and so pass on to consider what can be done to minimise their effect.

To consider, first, the case of prevention of decay in new buildings. I trust I have made it clear that we are constrained to use materials which are naturally prone to decay, and the first and most important consideration is that one must recognise this, and give them every possible chance, both in the design and construction of the building. I am not going to presume to discuss the influence of design, but I refer again to the fundamental importance of careful selection of the stone to secure the

*Dr. Tempest Anderson, Yorkshire Philosophical Society, 1910.

maximum possible durability, and careful supervision to ensure that it is laid in its natural bedding plane, except in exceptional cases where the design of the building precludes this. It may seem ridiculous to even mention this obvious point, but my idea that you never find a face-bedded stone in a modern building has been very rudely dispelled by a tour round some of our most important public buildings. I have been astounded at the number of face-bedded stones—even in the case of sandstone, where this is most disastrous--in some of our important public buildings erected during the past century. Of course, in a stone of very uniform texture, such as Bath, it is a matter of some experience to identify at sight the correct bedding in the freshly cut stone, and it may, therefore, seem unimportant, but exposure will always in the most heartrending manner demonstrate that this is not the case. Another indirect method of preventing decay is to further, by every possible means, the campaign for the purification of the atmosphere from the products of combustion of fuel, particularly as regards sulphur compounds.

Treatment of stone with protective solutions is the final link in the chain. No preservative has yet been discovered which will give Bath stone the endurance of granite, which is the ideal we aim at. At the same time, in my opinion, treatment is distinctly beneficial provided that the preservative is of known composition, adjusted to the character of the stone and the conditions of exposure, and applied under proper supervision.

The preservation of old buildings where decay has already taken place is infinitely more difficult than the protection of new ones—we have to take the building as it stands, and do what we can with it. In ancient times difficulties of transport rendered the choice of stone more limited. Unsuitable local stone was often used, and it was often badly selected and badly laid. Little precaution was taken to prevent the access of damp, and the designers, naturally, did not provide for the drastic conditions which prevail in modern times.

We have to bear in mind also that, up to a certain point, the weathering of stonework is a distinct advantage—we do not wish to destroy the time-honoured effect of old buildings any more than one would want new buildings to resist the mellowing effect of time. The drastic restoration of old buildings, the ruthless removal of every sign of decay and conversion to a bright new structure, is rightly deprecated at the present time. *So long as one possibly can*, the right thing to do is to leave an old building alone.

But when the effect of time passes, the limit of "a perfecting by God of the handwork of man," and decay becomes unsightly and unsafe, something has simply got to be done to arrest it, and to re-construct the already decayed stone. That is where the search for a reliable preservative which will protect the building without in any way detracting from its beauty becomes of paramount importance.

The properties demanded of a perfect stone preservative are many and conflicting, and may be briefly tabulated thus :—

1. It must penetrate easily and deeply into the stone, and remain there on drying.
2. It must not concentrate on the surface so as to form a hard crust, but at the same time, harden the surface sufficiently to resist erosion.
3. It must prevent penetration of moisture, and, at the same time, allow moisture to escape.
4. It must not discolour or in any way alter the natural appearance of the stone.
5. It must expand and contract uniformly with the stone so as not to cause flaking.
6. It must be non-corrosive and harmless in use.
7. It must be economical in material and labour of application.
8. It should retain its preservative effect indefinitely.

In discussing the present state of our knowledge of stone preservatives, it is hopeless to attempt to describe individually the principles and merits of the numerous proprietary articles which have been placed on the market in recent years; it would take a long time, and would not lead us very far.

You may not agree with me, but, personally, I object to the use of any material of unknown ingredients, and consider that the problem can only be rightly tackled by employing only substances of known composition under principles worked out by a chemist so that the method of application can be controlled. Even failure is not waste in this case, because at least you

have added a definite fact to experience, and it is only by the accumulation of such data that we can ever hope for progress. To make trials with preparations the composition of which is jealously guarded as a secret is, however, useless, because we can learn nothing from failure—we may, as a matter of fact, be experimenting with the same thing over and over again, because, in my experience, many of the proprietary articles are materially the same thing under a different name.

Careful study of the data concerning every process that I have been able to discover shows that, as regards the principles on which they act, they can be roughly divided into three groups :—

1. Those which only act as surface coatings.

2. Those which impregnate the stone without chemical action on it.

3. Those which operate by chemical reaction with the stone.

In the first category, we may place paint and limewash. The most durable paint - and here, perhaps, I am inviting controversy by implying paint made with white lead—undoubtedly acts as a fairly efficient preservative, but not, unfortunately, in the sense that we require, because it obliterates entirely all that quality of surface and texture which is the chief charm of a stone building.

Limewash has, however, been used from time immemorial as a protective coating, and is still largely employed. When properly made with boiling water so as to ensure the maximum quantity of soluble hydrate of lime, it can, to a certain extent, consolidate the friable surface of partly decayed stone, and it retards decay to a certain extent by reacting with sulphur acids and neutralising them before they can reach the stone beneath. Its effect in this direction is, however, only temporary, and to be effective it requires frequent renewal. This has the objection that being a surface coating, repeated applications tend to obliterate the details of any enrichments of the surface, and it can at best only be regarded as a temporary expedient. Limewash has the advantage of economy, and can be safely used in many cases in the absence of a more perfect method, more particularly in situations where it can readily be renewed, and where the stone is subjected to a moist atmosphere but protected from direct rain. I mean, for instance, cloisters, where there is no direct washing effect, but where fog, which of all things is the most harmful because it contains the maximum of corrosive acids, has free access.

The second class of preservatives are those which operate on the principle of impregnating the surface of the stone with a material which prevents the penetration of moisture, and is highly resistant to chemical action. The most obvious material to use for the purpose is mineral wax, which is composed of solid hydrocarbons. Hard paraffin wax is highly resistant to the action of acids, and is impervious to moisture. A solution of wax in benzene or similar organic solvent, has formed the basis of many preparations, disguised under some fancy name.

In theory, a preparation of this type will penetrate the surface of the stone, and render it impervious and resistant. It is, in fact, quite easy on a small scale to produce this penetration, and to demonstrate that the surface, so treated, is consolidated and rendered immune from decay. In practice, however, on the large scale, this theory does not work out. In order to allow penetration of a substance which will not mix with water, it is necessary for the stone to be absolutely dry, a condition which rarely obtains in this country in a building exposed to the weather. Wax is, moreover, only sparingly soluble and a liquid preparation of this kind only contains a small proportion. The result is that on application the solvent rapidly evaporates and deposits the wax as a loosely coherent film on the surface, which soon scales off and does not efficiently protect the surface.

A more hopeful method of applying wax is to drive it in by means of heat. This encaustic process is one of the most ancient methods of water-proofing a surface. It was introduced by the Greek artists, not so much for preservative purposes as for giving a polished surface to painted plaster, as, for example, at Pompeii. The late Professor Church's method of encausticising was to make a paste of ceresine wax and toluol, about the consistency of vaseline, spread this in a thin layer on the stone, allow the solvent to evaporate and then melt the wax by local application of heat, when it soaks into the stone.* A similar process has been employed by Dr. Caffal in America—notable for the treatment of

*Conservation of Urban Stone-work : R. Institution, 1907.

the Obelisk in Central Park, New York. This treatment is undoubtedly effective for certain purposes. For the protection of mural decorations in fresco and tempera it is very useful, and I have employed it myself successfully for that purpose. I consider it useful also in certain cases for the protection of delicate carved stonework which is shewing signs of decay. But for general use on buildings, especially for exterior work, it has fatal objections. Its effective application is slow, and requires skilled labour, so that it is extremely costly; moreover, wax, unfortunately, softens in hot weather with the result that dirt adheres to it, and the treated surface becomes very unsightly. Again, as it is practically impossible, on the large scale, to ensure that the stone is perfectly dry before application, the effect of forming an impervious coating on the surface area is that in hot weather the moisture locked behind it develops sufficient pressure to burst through, causing disruption and flaking.

The one outstanding feature of the encaustic treatment is that you *can* drive the material well into the stone, and get penetration, which is the great stumbling block with all methods in which the preservative is applied in the form of a solution. Professor Laurie has clearly demonstrated* that even when application of the solution results in penetration to a considerable depth, it by no means follows that this penetration remains at the finish, because, as the solvent used to reduce the protective agent to the mobile liquid necessary for penetration evaporates, the preservative is drawn back to the surface by capillary attraction, and finally forms merely a thin coating on the surface, which tends to scale off.

The next group of preservatives in this class are those in which drying oils or fatty acids are the principal ingredients. According to Professor Laurie, linseed oil, reduced to the requisite viscosity with a volatile thinner, fulfils better than any other solution the most essential condition of penetrating the stone. Impregnation with boiled linseed oil has long been practised; it has, however, the disadvantage of causing discoloration and is not chemically stable, gradually oxidising and becoming friable. The durability can be increased by sulphonating the oil by heating it with sulphur, a process for which Daines took out a patent in 1854. This preparation has been used both for impregnating stones before fixing, and treatment of partially decayed work. The results of treatment are in general successful, from the point of view of protection, but disastrous from an æsthetic point of view, owing to the discolouration. This material could be used with advantage for dark ferruginous sandstones, but for a stone like Portland, it is hopeless. A more satisfactory oil preparation has been used for some time in America, in which linseed oil is replaced by Chinese wood oil, reinforced with rosin and fatty acids.

As far back as 1850, however, Sylvester endeavoured to secure better durability by using saponified linseed oil in place of the oil itself; this being miscible with water pentrates the stone more easily. His method was to dress the stone first with a solution of alum in water, followed by a solution of soft soap, both being used as hot as possible. As a result, the aluminium salt of the fatty acids is precipitated in the stone, and this is insoluble and tough, and forms a consolidating or binding agent in the stone. It has the disadvantage of forming potassium sulphate as a bye-product of the reaction, although this does not cause serious efflorescence. It cannot be relied on for protection for more than a few years, when re-dressing is required, but it certainly consolidates decayed stone and does not cause discolouration. Up to the present, no more satisfactory material of this type has been produced, and it has the advantage of being very economical and easily applied. I prefer it, therefore, to other organic preparations for the re-consolidation of decayed stone, although it is by no means a perfect preservative.

Numerous other organic impregnations, such as creosote, casein and solutions of resins in alcohol have been tried without much success. Professor Laurie considers that the most hopeful line of progress lies in the direction of a suitably prepared solution of resins, but his final results in this direction are not yet available. Meanwhile, one may say that all organic preparations at present known may be grouped together as effective for a limited period, but failing to give a permanent protection owing to decomposition.

Another group of preservatives employs the principle of depositing an inorganic precipitate of a gelatinous character in the

*Journal of the Society of Chemical Industry, May, 1918.

stone. Various salts, such as aluminate of potash, barium phosphate and barium sulphite, have been tried, but always with the result of forming a crust on the surface as the solvent dries out and causing scaling.

To come to the third class of preservatives, those which react chemically with the stone, I will mention first the baryta treatment, associated with the name of Professor Church, with this proviso, that I consider it stands in a class by itself, as not so much a preservative as a corrective or re-constructive agent only applicable to one specific case, that of a stone that has been disintegrated by the action of sulphuric acid. As a preservative on new stone or stone which has suffered what I have called natural disintegration, it is quite inadmissible. I want particularly to emphasise this, because I find by experience it does not seem to be generally understood. When a limestone or calcareous sandstone is exposed to an atmosphere containing sulphur acids, disintegration occurs, owing to the formation of calcium sulphate. Barium hydrate, which is an akaline substance somewhat similar to caustic soda in its properties, will react with the calcium sulphate to form the highly insoluble and inert material barium sulphate. At the same time, it sets free the lime as calcium hydrate, which by absorption of carbon oxide from the air reconstitutes the original binding cement. Considered in this light, it is obvious that, unless sulphates are present in the stone, its application is useless, and that it does not protect the stone from further attack. In my own experience, whilst I have frequently found as much as 20 per cent. of calcium sulphate in interior stonework subjected to the prolonged effect of gas lighting and heating, I have rarely found more than 3 per cent. in the decayed stone of exteriors, where it is exposed to the washing effect of rain. I attribute this to the fact that the sulphates being freely soluble in water are dissolved and washed away as they are formed, so that baryta treatment seems to be in general quite useless for exterior work.

But I consider this process distinctly serviceable for special and limited application, and occasionally advise its use for special purposes, notably in the interior of buildings where carved work or mouldings have become soft and powdery on the surface, owing to the employment of gas lighting. It must be used with moderation, the amount of sulphates present in the stone determined by analysis and the strength of solution adjusted accordingly. Used in excess, it undoubtedly does more harm than good, because the excess of barium salt rapidly carbonates on exposure to the air, forming a hard crust of barium carbonate which scabs off owing to difference of expansion. Its too enthusiastic use on all kinds of stóne, particularly on exteriors, is positively dangerous and is, I consider, largely responsible for the fact that the process is generally discredited now.

To pass on to the chemical preservatives proper, the principle underlying the majority of preparations of this nature is the deposition of silica or silicates to reinforce the natural cement of the stone. The earliest attempts in this direction consisted in dressing with a solution of sodium or potassium silicate, popularly known as water glass, which is gradually converted into insoluble silicate of lime by reaction with the stone. But in any process involving a chemical reaction, it is essential to take into consideration the bye-products of that reaction. In the case of water glass, the result of this action is to liberate caustic alkali, the effect of which is disastrous, producing unsightly efflorescence and rendering the stone hygroscopic

Attempts were made later to minimise this effect by alternate dressings with water glass and calcium chloride, which is well known to react with sodium silicate to produce calcium silicate together with colloid silica. But the result of this treatment is to produce common salt as a bye-product, which is not at all desirable. The use of calcium chloride as a precipitating agent has the added disadvantage of being deleterious if used in excess. Owing to its well-known property of attracting moisture, its presence in the stone tends to keep it damp. A more hopeful method of using silicates is that due to Mr. Hemingway, who proposed to dress the stone first with a weak solution of water glass and then with a solution of arsenic acid, which reacts with the silicate of soda and the stone simultaneously forming a precipitate of gelatinous silica and arsenate of lime which acts as a binding agent. This process has been extensively used, and gives fairly satisfactory results, but the difficulty with it is that the reaction takes place at the surface with the result that a hard surface skin is formed which peels off after a few

years' exposure. This process also does not obviate the difficulty with all water glass processes that alkali is released as a bye-product of the reaction, which is liable to cause unsightly efflorescence. Many attempts have been made to introduce soluble silicates into stone without using alkali, but little progress was made until in 1883, Kessler* introduced the use of fluosilicates in France By the combination of silicic acid and hydrofluoric acid, one obtains an intermediate product known as hydrofluosilicic acid, which has the the peculiarity that it forms soluble salts with magnesium, zinc and aluminium. By this means one obtains a siliceous solution entirely free from the objectionable alkali. On treating limestone with such a solution of magnesium fluosilicate, the following reaction takes place :—

$$MgSiF_6 + 2CaCO_3 = SiO_2 + MgF_2 + 2CaF_2 + 2CO_2$$

that is to say, that the fluosilicate forms with the lime, fluorspar and free silica, the only bye-product being carbonic acid.

Magnesium fluosilicate has been manufactured in France for many years, and is imported into this country and supplied under the abbreviated title of "Fluate." The process has been in use here for some 30 years, but the results obtained have been very conflicting. Whilst in some cases it appears successful, in most instances it is considered to have no appreciable preservative effect and to result in the formation of a hard surface skin which causes flaking. Sir Frank Baines has kindly given me facilities for examining some of our public buildings where Fluate has been used, and I must confess that I am not quite as pessimistic about the results as the Office of Works. Whilst decay has certainly not been prevented to the extent that has been claimed for it, I certainly think it has proved beneficial to some extent, and that the scaling of the surface is exceptional.

In France, fluosilicate treatment has been practised for years on Government and other buildings, and the results are considered satisfactory. Fluosilicates are also manufactured in the United States for use as a stone preservative, the double salt of magnesium and zinc being mainly used, with generally satisfactory results.

*Comptes Rendus, 1883-96, 1317. See also C. H. Desch, Journal of Society of Chemical Industry, April 30th, 1918.

A possible explanation of the comparative failure of this process in this country may be that the method of application recommended, which is broadly to dress the stone first with a 15 per cent. solution, followed with a 35 per cent. solution, is not adjusted to the conditions of exposure here.

The use of fluosilicates, and particularly the point of the method of application has recently formed the subject of investigation by Professor Desch in conjunction with the Department of Scientific and Industrial Research. After carefully surveying the buildings treated in France, and confirming the fact that the treatment appeared to be successful, he examined the process as used here. Unfortunately, his detailed report has not yet been published, but I gather that his conclusions are, in general terms, that the solution is generally used too strong, and that a single specification cannot be used for all cases—the strength of the solution (which should never exceed 10 per cent. for first dressing), and the mode of application should be adjusted to suit the particular stone and conditions of exposure.

These conclusions coincide with experience in the United States and are, at least, suggestive that the scabbing and scaling reported in some of the fluated buildings in this country is largely due to a hard surface coating having been formed by using too concentrated a solution. Like every other preservative, fluosilicates cannot be used indiscriminately on every kind of stone. The process is most suitable for pure limestones of uniform texture, such as chalk or Bath stone, where the solution can act on the aggregate. For sandstones I consider it of doubtful value, as the action of the solution is limited to the cement. Professor Desch claims that previous dressing with a saturated solution of lime water, renders treatment successful in such cases, but I confess that I am sceptical on this point.

I consider also that the principal value of fluosilicates is as a preventive treatment on new work. As a preservative on stone already decayed and powdery, it is of less value, as the consolidating substances are not sufficiently tough to form a good cement. Although the use of any material which reacts chemically with the stone is condemned by some authorities, notably Professor Laurie, the use of substances of the

nature of fluosilicates seems to me to be the most promising line of research, although it must be confessed Kessler's process, as at present used, cannot be regarded as anything approaching a complete solution of the problem.

The possibility of impregnating the stone direct with soluble silica has also been investigated, but the process is very slow and tedious—for treatment of small details it is practicable, but for general application is quite out of the question.

This concludes a very condensed summary of the principal attempts that have been made to solve this important problem. Not the least of the many difficulties in the way of research is that of finding a method of testing the value of a process with any approach to service conditions. Accurate measurements of water absorption and crushing strength give an indication of the water-proofing and hardening effect, but it is difficult to interpret the results of such tests on small samples in terms of weathering on a large scale, with all its complicated factors.

Various methods have been tried for determining the effect of weathering artificially. Professor Dodge* some time ago proposed to determine the resistance to natural weathering by suspending test pieces of known area and weight in water through which a stream of carbon dioxide was passed and determinging the relative loss of weight. Professor Laurie† recommends placing similar test pieces under a bell jar in which they are subjected to the fumes of hydrochloric acid for a given time, and determining the loss of weight. Dr. Desch utilises the atmosphere of an ordinary laboratory fume cupboard in a similar manner. I have attempted myself to produce an "accelerated atmosphere" by exposing the stone to water vapour under pressure in an autoclave, and determining the effect under known conditions of temperature, pressure and time of exposure. Such laboratory methods, applied to service conditions, are in general unsatisfactory. On the other hand it is impracticable to determine the effect of varying the method of treatment and application by making exposure tests and waiting ten or twenty years for the results.

We can, however, pretty well make up our minds to one thing—that we are not likely to discover a process for converting a soft limestone into a material which will resist all the agencies of decay indefinitely, and be capable of universal application to all kinds of stone under all conditions of exposure.

The preservation of stone probably always will remain a matter of careful supervision; the utmost we can hope for is to be able to prevent decay for a considerable period by treatment varied according to the nature of the stone and the conditions of exposure, and at present we are far from even being able to do that.

But whilst progress is thus slow and uncertain, the decay of our historic buildings is quite the reverse. Something has to be done, and it is on the principle that it is better to do what one can at once than wait for the millennium, so slow in coming, that I have attempted in this paper to review the present situation and express my views in the hope that they may be of some practical assistance to the architect.

Let me now summarise for criticism and discussion the conclusions I have arrived at:—

1. New work can be rendered to a certain extent more resistent to decay by treatment with fluosilicates, provided the strength of solution and method of application is adjusted to suit the stone used.
2. No preservative treatment will be effective on faulty or face bedded stones.
3. Constructional methods of reducing decay (prevention of damp, effective carrying away of storm water, etc.), are more important than preservative treatment.
4. For outside work on old buildings no preservative at present known serves to preserve decayed stone for more than a limited period. The most economical treatment is dressing with soft soap and alum, renewed every few years.
5. In interiors, where the stone has been corroded by sulphur compounds, baryta treatment is, in many cases, beneficial, but it should only be used with restraint and under careful supervision, and should be followed by distempering.
6. Preservative treatment should only be employed where it is certain that it can, at the worst, do no harm. For this reason articles of unknown composition should be avoided, and only materials used the action of which is well understood.

*Geological and Natural History Survey of Minnesota, 1872.
†"The Builder," October 15th, 1920.

Progress towards the goal can only be obtained by constant exchange of experience and study of results. That is the line I have pursued, and I want, in conclusion, to express my gratitude for the unfailing assistance I have received from the many to whom I have applied to check the results of my own experience. In particular, I have gratefully to acknowledge that this paper would have been a very sorry affair without the support of Sir Frank Baines, who has placed all the resources of H.M. Office of Works at my disposal for collecting and checking information. The majority of illustrations and specimens I have been able to show you have also been placed at my disposal by the Office of Works. In short, the generous encouragement that has been showered upon me cannot be over estimated.

DISCUSSION

THE CHAIRMAN (Sir Frank Baines, C B E, M V O), in opening the discussion, said he was sure all those present would agree with him that they had been privileged to listen to a paper of a most distinctive quality It had been admirable in the way it had brought forward for review the vast area of the problem of the preservation of stone, and it had been admirable also in the conservative point of view from which the author had approached the problem and in the scientific reserve with which he had appraised the various proprietary preservatives which had been put upon the market. The first point he wished to mention was that architects, people dealing with construction, had in the past been in the habit of regarding stone as a permanent material, but stones were not permanent materials; in their very structure was the essence of decay. The early igneous and volcanic rocks had been corroded and broken down and had been the parents of the later sedimentary rocks, which had in their turn been broken down and reconstructed, and it was, therefore, essential to recognise that stones were entirely impermanent in their character and structure When the atmosphere in great urban areas at the present time was also taken into consideration, it would be realised that it was extraordinarily difficult to evolve a solution of the problem of the preservation of stone It seemed to him quite clear that the character of the decay was of special importance The author had referred to the character of the decay of the magnesium limestone of which the Houses of Parliament were built. In that case apparently the utmost care had been taken to select a stone which would resist the effect of the London atmosphere, but the result had been a complete failure. That had to be attributed to the inadequate way in which the attempt was made to deal with the subject in a scientific manner. There were two problems to be considered in that connection. One was the surface decay of the stone, due to the action of sulphuric acid and sulphurous gases on the magnesium carbonate, which resulted in sulphate of magnesium being formed on the surface of the stone. The particular difficulty occurred, to which the author had referred, of the stone being subject to minute strata of foreign material across its bed With regard to that it was surprising to find across those strata, far removed from the surface of the stone, a very fine deposit of pure sulphate of magnesium, showing that the decay had gone on right in the middle of the stone, that the weathering qualities of the atmosphere had been such that they had penetrated the lines of cleavage and disintegrated the stone The problem was an appalling one, and if it was dealt with drastically, tens and even hundreds of thousands of pounds could be spent on it He thought it was due primarily to the London atmosphere and in part to the fact that those responsible had been so ill advised as to select a magnesium limestone, which he thought in the London atmosphere was infinitely more dangerous than a pure limestone. The Office of Works had attempted to collect data with regard to the subject, and sent a very detailed questionnaire to the British Ambassadors in France, Germany, the United States, Italy and Greece, with practically no result, which showed that there was very little collated information on the problem abroad He thought the author had shown that there were more collated data in this country than anywhere else When it was found there was very little information to be obtained from abroad, the Office of Works finally decided that as a Department they could only put themselves in the hands of the specialist. It was their invariable practice to do that when they felt they could not tackle a problem themselves They relied upon Dr. Church's method of treating stone with baryta water, thinking they had got the considered opinion of a fine scientific brain, which would give them the solution. The author had referred in his paper to the methods adopted in applying the baryta treatment, and the criticism he made was quite a legitimate one, but the application was directed entirely by Dr. Church himself. It was Dr. Church's own view that perhaps a too partial treatment would not give satisfactory results, which, it had to be pointed out to him, were not obtained. The decay of stone was generally due to the formation of sulphate of calcium on the surface of the stone, and that material when it was formed had practically an increase of 150 per cent. in volume over its form as calcite. It was, therefore, by the very act of crystallisation and expansion in volume inevitably liable to cause exfoliation of the surface of the stone, and there was not the slightest doubt that Dr. Church's baryta

treatment would cause exfoliation, because, by turning the calcium sulphate into an insoluble barium sulphate, it again reduced the volume by the formation of the barium sulphate and exfoliation occurred. He, therefore, felt that in no case could it be logically expected or believed that the baryta treatment would lead anywhere, and the Office of Works had entirely discarded it at the moment. They then asked Dr. Laurie to investigate the problem with them and attached very drastic conditions to the investigation, conditions which probably no other authority would impose in putting the problem before a specialist. They said that they were so subject to criticism, not only because of their bureaucratic standing, but also because of the undesirable things they were so liable to do, that they were not prepared to deal with the problem of stone preservation if it involved taking any single fragment from the decorative stone work which had been placed in their care as a national charge. They, therefore, said they would have no solution which would lay down as a principle that the work had got to be scraped or wire brushed, or—as he remembered the manufacturers of a certain proprietary article wanted him to do—that they had to chisel back to the hard work and then apply the preservative. Dr. Laurie accepted those drastic conditions so thoroughly that in certain work that had to be done on a building of great historic interest, he decided not even to spray the stone heavily but to treat it by flicking the solution he used on to the stone with a camel-hair brush until it was absorbed. It was absolutely necessary to lay down conditions which would ensure that the stone should not be treated in any other way than with the utmost reverence. The Office of Works had examined, with the assistance of their specialist, about 60 proprietary preservatives. Of those, 28 came under the category of those which acted chemically upon stone and 32 came under the category of those which filled up the open pores of the stone. It was found, on the advice of the specialist, that there was really very little hope in respect of any of those preservatives, bearing in mind that the aim of the Office of Works was to finish with the buildings for at least a decade or so and leave them to the mellowing hand of time, without continually touching them up. The author seemed to imply in his paper that the minute growths of lichens and mosses on stone were not really detrimental to it, but personally his experience had been that those minute growths did actually disintegrate stone, and he could bring forward most direct evidence of that. The Office of Works, however, did not propose to eliminate them altogether; ivy and the major destructive influences must be eliminated, but they did not advocate the elimination of lichens, mosses and moulds, which added so much to the beauty and character of old buildings. The problem of the Office of Works was mainly how to preserve with the greatest degree of care the beautiful historic buildings which were handed into their charge for the delight and interest of future generations, and he was afraid he did not take much interest in any method of treatment which could only be used effectively in the case of new stone. When he was told that the fluate treatment might be effective on new work it did not interest him very much and he was not prepared to argue whether it was a material contribution to the subject. Another point he would like to bring forward, was whether the whole question of stone decay had been fully investigated from the petrological point of view, whether it was certain that the maximum advance in the whole enquiry had been made on that ground. He felt that if micro-photographs of the thin scale and surfaces of various stones were to be taken, and their structure ascertained from the point of view of physics, as well as of chemistry, more data would be obtained as a guide in any future action taken with regard to the preservation of stone. He thought too little had been done in that connection to warrant the statement that the subject had been exhausted. Another important point was one which the author emphasised more than once in the paper, namely, the tremendous importance of making architects realise the need for placing the stone in position in a proper and adequate manner. That was of enormous importance, in his opinion, because it must be realised that stones were impermanent in their character, and it was necessary to try to re-produce in buildings, if possible, the conditions under which the stones were deposited in the quarries, so as to render them as stable as possible. Whether that could be done adequately or not was a point to be questioned. Stones in the quarry were subjected to tremendous lateral and overburdening pressure; and when they were taken out it was found that some had quarry sap in them and some were hardened up and weathered when they were removed, and they were put into buildings under varying conditions and expected to stand satisfactorily. As an example, York stone was used to-day that was subjected to enormous superimposed pressures in the quarry, and when it was put into plinths and parapets it split and clove, mainly because of the relief of pressure and not because of the sulphuric acid content of the atmosphere. Granites themselves were subject to very material decay. In walking round the great granite cliffs of Cornwall, he found the most distinct signs of breaking down of the granites by the pure air, the granite rocks of those cliffs showing all the particles of quartz entirely separated, and the felspar was apparently entirely disintegrated and broken up, probably partly by the action of the pure rain water, which in itself was a solvent, and partly by the action of carbon dioxide on the felspar and the mica. With regard to another stone which was supposed to be a most permanent and solid

one, Craigleith stone, he saw in Edinburgh many signs of the decay of that most admirable weathering stone. With such a small proportion of pure calcite in the stone, he did not think the decay could be due to sulphuric acid in the atmosphere, but he thought it must be the result of temperature stresses. When a stone was being dealt with in which the crystals were associated together in the most dense and solid form, there was very little room for expansion and contraction under temperature stresses, and that was probably the cause of the breaking up of the stone When such stones as granite and Craigleith broke down under mechanical actions of temperature stress and wind erosion, and so forth, it seemed to him inevitable that the other stones, containing, as they did, an agglutinant and an aggregate of pure carbonate of lime, would be broken down by the atmosphere in this country to-day, and it was, therefore, very important to deal with the question of purifying the atmosphere by resolution of the crude coal problem. The difficulty he had, as an empiricist with little chemical knowledge, was to understand how there could be any solution which would turn a soluble sulphate of calcium into an insoluble salt of some kind, and yet remain on the work married back to the stone without exfoliation? He did not think it possible that in turning soluble sulphate—increased in volume, in the case of magnesium limestone, to the extent of about 400 per cent in the act of crystallisation—back to an insoluble material the question of stone preservation would really be dealt with He felt that every conceivable solution had been dealt with and that the physicist must come into the question far more than he had done in the past With regard to the methods adopted for stone preservation which were of a greasy character, Dr. Laurie did very valuable work for the Office of Works in investigating capillary phenomena in the pores of stones, and showed quite definitely that, owing to conditions of the surface tension of the material, where the solutions applied to the stone were of a greasy character there was an inevitable result that the whole of the solute of the material returned by capillary attraction to the surface layer of the stone. The author brought out that point very clearly, but what Dr. Laurie said was that unless the question of surface tension was further investigated he was not prepared to say that any solution would do other than return its solute to the surface of the stone, particularly when the stone had been subjected to the greasy atmospheric deposits of a large urban centre. If that was so, it was perfectly clear that that aspect of the problem must be dealt with first, and if it could not be solved it would be found that the stone scaled on the surface, because of the purely capillary phenomena. He felt it was most dangerous in the question of stone preservation to deal with any method which postulated that the solution would attack the natural agglutinant of the stone itself. Nature provided a particular agglutinant for certain stone, which happened to be calcite, and yet people were prepared to break down that calcite and put something else in its place. He was perfectly certain that disaster would follow that method The Office of Works was investigating methods of dealing with the preserving of decayed stone by using organic substances, and he thought the chemist ought to say something about that. He could not conceive in his own mind that organic substances were ever likely to be in any way permanent in the sealing back of the disrupted particles of decayed stone. Dr. Laurie had pointed out that certain organic substances such as ambers and resins, were very stable, but he thought it was very doubtful whether those ambers and resins would remain in the stone without altering its character That was a point on which the chemist might be able to give information He came across one very interesting fact in looking into the question of stone preservation, and that was in the various researches made by Dr. Tempest Anderson in 1910 Dr Anderson considered that decay was caused partly by organisms similar to moulds and fungi, for which dirt and damp formed a developing nidus, and he definitely produced thousands of colonies of unidentified bacteria which he was not in a position then to say were detrimental, but he rather considered it inevitable that they would be detrimental That was a line of enquiry which ought to be pursued, and it bore materially on the point brought out by the author, that he would prefer to see the minute lichens remaining on the stone There was another point that should be brought out very clearly. He had seen stones that had been pointed, stones of very old buildings, and the pointing had been kept back from the surface and the decay had gone on, and the modern pointing put in to preserve the joint and keep the water out, was now standing out ½in. in front of the stone which was previously in front of the pointing. How was it that the modern lime pointing put into old work stood up to the acid attack of the atmosphere and the old stone did not? It was a very curious fact There were examples of Roman pointing at Richborough 1,700 years old, and the pointing was nearly as perfect as the day it was put in. What was the reason for that? Was it the silicates and colloids formed in the pointing or what was it? That might be a line of enquiry which would produce some suggestion as to further attempts that might be made to arrive at a solution of the problem. When he saw Dr. Laurie, a few weeks ago, he said to him: "With regard to your new solution, which is a solution of pure resin dissolved in toluol and certain other additional substances, we do find that it firms up the stone under the most drastic conditions, when flicked on with a camel-hair brush. I receive reports from my

staff that stone the face of which would have been destroyed by a touch has been firmed up and can now be tried with the nail of the finger and is quite firm. My staff tell me it is most hopeful.'' Dr. Laurie replied: "I wish I could believe that their view was correct. I want to know how long the effect will remain.'' He said: "Therefore, you do not think that this solution, which is getting us better results than we have ever had, will necessarily be permanent ?'' and Dr. Laurie replied in the negative. He then asked: "Would you, therefore, consider whether it is possible to produce a clear, colourless flux on the surface of stone which on the application of heat would not alter its colour but would seize the whole surface of the stone? Would you investigate that problem?'' It was of course, a problem for the physicist and the chemist, but it might be that advance would take place on those lines, and he had arrived at the following position He postulated that the whole great wall surfaces of buildings could not be preserved by the application of any special solutions, and that it was necessary to concentrate on the carved, moulded, and other specially worked surfaces Therefore, he believed that any method which would give a measure of stability to those portions of the building would be invaluable, and the problem ought not to be considered from the point of view of the tremendous expense of applying some system to a whole vast structure, but should be considered from the point of view of applying some system to the moulded and specially worked surfaces only, which had such great interest for the architect, the archæologist and the artist.

Mr J Allen Howe, O B E. (Assistant Director, Geological Survey of Great Britain), said he thought it was no use trying to get solutions of any kind into old rotted stones situated in a building, because it was impossible to get them in far enough Not a single process had yet been devised for doing that, and it was not likely that one would be found; its practical application was opposed by all the laws of Physics. It might be done if the liquid used were very carefully and continuously soaked in by poulticing, as had been suggested by Prof. Laurie, but this was not economically possible on an extensive scale. That was the definite conclusion he had come to after studying cases of decayed stone in very many buildings not only in this country but abroad for a good many years. The problem of preserving the stones of new buildings might not be so interesting as the problem of preserving them in old buildings, but it was probably quite as important, and certainly not so difficult. Buildings were now being put up of Portland stone and other materials, and they would have to be dealt with by the Office of Works in the future. It must be remembered that fashions altered; a little while ago all the decayed stones were pulled out and new ones put in, more or less like the originals, and everyone was quite satisfied, but people to-day did not like this. It seemed to him an insoluble problem because we could not afford the cost demanded by the prevalent fashion in taste. With regard to the author's remarks about the difference between Bath and Portland stone and the reason why they did not behave in quite the same way on weathering, he thought the reason was quite clear The internal structure of the two stones was very different, and he thought the essential difference between them was that in Portland stone there was very much greater agreement in texture and so on between the ooliths and the matrix in which they were situated. That was really the key to the difference between them. With regard to the question of face bedding, a great many stones were found placed in that way, but he thought perhaps the author was a little unfair to Portland stone, if he included it in his strictures He thought all architects and builders would agree with him If one looked at the piers of the railings round the Natural History Museum, they showed what bedding in this stone really was Of course, in some cases it showed true bedding planes, but very often it was really a false bedding, and that could be seen beautifully. It did not hurt the stone at all, because the cohesion was so uniform that it did not matter which way the stone was laid He was very grateful to the author for putting the case regarding preservatives so clearly, and what the author had said was very much in accordance with what he himself felt about the matter.

Dr J J Fox, O B E, F.I C (Government Laboratories), said he was very gratified to find that the author had brought together all the information that was scattered about on the subject of the preservation of stone. There were two ways of treating stone with a solution: one was to fill up the pores of the stone and so render the whole impervious, and the second was merely to coat the granules Personally he had a natural aversion from filling in an old monument; he would rather let it alone and do nothing to it. Sometimes, however, it became necessary to do something, as, for instance, when it was desired to keep an inscription in place In that case something might be done with a solution in one of the two ways he had mentioned. The information available on the whole subject was rather deficient In the 1861 Reports on the Houses of Parliament, it would be found that a recommendation was made that a small sum of money should be spent on testing some of the solutions proposed, for it was considered that there was no way of deciding the value of them except by the lapse of time. If the recommendation had been adopted, there would now be available a good deal of information on some of the solutions which were claimed to be preservatives.

There was one point in connection with soot that ought to be known, namely, the destructive effect of the ammonium sulphate contained therein. If a piece of Portland stone was dipped into a very weak solution of ammonium sulphate and the solution was then washed off, a permanent mark was left and calcium sulphate would be found. The action of ammonium sulphate in the soot was entirely different from that of sulphuric acid, but it was an effect that could not be ignored. There was also a point in connection with treating stone with natural gums, linseed oil or resin, which ought to be known rather more widely than it was at the present time. It had been found that, if limestone was treated with some of the resin acids, the stone was actually disintegrated to form calcium resinates. Therefore, although the particles of stone might be held on by being treated with solution and the treatment might be effective for several years, ultimately it would fail. Similar remarks applied to linseed and fatty acids. He deprecated the use of soaps or fatty acids made from any oil like linseed oil; they were unsaturated and chemically very active substances. They were used, however, and if they had to be used at all he would recommend the use of a pure calcium stearate. He had studied the whole subject very carefully and he did not know of anything of universal application. He thought each case must be treated individually and it was frequently best to leave it alone. There were cases in which some good might be done, but he thought they were very limited in number. He believed the baryta treatment would be a failure in most cases.

MR A R POWYS (Secretary of the Society for the Preservation of Ancient Buildings) said that, in passing through a doorway under an arch where the stones above one's head were crumbling with decay, it was very often noticed that those which came in contact with the shoulder as one passed through were perfectly sound and the moulding was not at all decayed. He imagined that might possibly be due to some grease or other substance from the human beings passing by and rubbing their shoulders against the stone, or possibly the simple removal of dirt collecting on the surface was sufficient to prevent decay for a long time. In the case of an altar slab with a canopy over it, it was sometimes found that the edges of the altar slab, which were touched by the hand, were perfectly sound, whereas the canopy was inclined to decay and fall in dust. The reason for that might be that the canopy was never dusted or kept clean, or it might have something to do with ventilation. He would like to know more about the cause of the difference. The second point he wished to mention, to which he did not think the author attached sufficient importance, was the use of limewash. He thought it was the invariable custom in mediæval times to limewash buildings. That custom died out during the last century. Buildings that were not used, such as ruined abbeys or castles, had never been re-limewashed since they fell into decay. But where the practice of limewashing had been carried out continually, buildings being limewashed once in fifty years or even more frequently, such as cottages and the lesser farm houses in country districts, the stone work was found to be perfect. Mr. Heaton implied that when a building was limewashed the quality of the stone was lost. It was true that the chisel marks were not seen so clearly, but on approaching a building that had been limewashed one would never take it for any other than a stone building—the stone was quite clear through the limewash. The surface might not have the same beautiful qualities of stone work that was left unlimed, but it had other qualities which were equally beautiful. From his experience of preservatives for stone, he thought limewash was the most certain. It was a preservative that was well understood and it had been used for many generations and was not by any means in the experimental stage. With reference to the author's remark that limewash was apt to be washed away by rain on the surface of a building, by looking at the old cottages and farm buildings where the practice of limewashing had been continued, and where the limewash had been properly applied, it would be found that that was not the case.

MR. GEORGE HUBBARD, F.R.I.B.A., F.S.A., said there was one question he would like to ask the author. In the case of driving rain, of course the rain would penetrate stone, and when frost occurred he presumed that that moisture would freeze, and that the process of freezing and expansion of the moisture would destroy the surface of the stone. In a general way, one would suppose that the denser the stone the more permanent it was, but the denser the stone the less space there was for that expansion of the water when it froze. From the point of view of freezing alone, would not a stone which was loosely composed be able to weather better than one which was very closely composed?

MR. ALAN E MUNBY, F.R.I.B.A., said that architects were interested in the problem of the preservation of stone, and had been attempting to find a solution, with the very great help of Mr Howe, not in connection with preservatives, but in making weathering tests upon the stones themselves. Mr. Howe had not said what his Department had done in that connection, and the report on the subject was not yet published. He might say, however, that certain common building stones had been under test for about ten years, and very interesting results had been obtained which established to some extent the order in which the common building stones

might be regarded as weatherers in London. There was only one point he wished to raise, namely, the possibility of getting into the stone a solution of silica. He had always felt that detriment was caused to stone by treating it with re-acting chemical solutions, but if the solution of pure silica was used, five per cent. in water, would it be possible to get that solution into the stone, to a greater depth than was usually the case, by attempting to dry the stone by piercing it to some depth in certain places with ventilation holes? That method of drying stone by ventilation had been used quite successfully by M. Knappen, but there was no necessity to use a tube such as was employed. If holes were bored in the stone a distance of about a yard apart, that would produce a current of air which would withdraw the moisture from the interior of the stone, and that would surely help the solution of silica to find its way further into the stone than it would do in the ordinary way. He thought that was a point that might well be investigated. He wished to conclude by thanking the author very much for his most interesting paper, which crystallised the whole matter, and brought all the information together in a way that could not fail to be of very great service to those interested in the subject.

Mr F W Troup, F.R I B A, said that as an architect he had very often tried to avoid using stone and to use bricks instead! One point had occurred to him which hardly bore on the question of old buildings, and that was in connection with the quarries In the larger quarries there was probably no difficulty in obtaining men who were really able to deal with the stone properly, and to reject the bad stone, the stone that could not be used, but there were small quarries all over the country and latterly they had been more or less neglected. When an architect came along and wanted to use a local stone, it was no use his ordering it to be cut out of the quarry if the old quarry men had gone A man could not become a quarry man by simply joining a Trade Union; he had to be born and bred to it: and that was a great difficulty which architects had in attempting to use stone in different parts of the country They had no difficulty if they were within reach, say, of the Bath stone quarries or the Portland stone quarries, but in many cases he thought it was rather hopeless to insist upon using the stone from the local quarries With reference to preservatives, he had used one in the case of Bath stone in London about thirty years ago, but he had only seen the building for five or six years after the preservative had been used, and, therefore, did not know what the result was now. In the case of Bath stone, however, it seemed to him it was very difficult to judge of the result of a preservative, as the stone varied so much in quality. Bath stone that was very carefully selected was sometimes nearly as good as Portland stone, but 50 per cent. had to be rejected in order to obtain that quality, and, therefore, a test of the kind to which he had referred did not give a very conclusive result.

Mr. Laurence A. Turner, speaking from the point of view of the stone carver, said that after stone had been masoned and put on a building, it probably stayed there for a year or more before it was worked by the carver, with the result that when the carver began his work he cut away the hard face of the stone formed by the quarry water and it did not come again He was rather surprised that the author did not mention quarry water in the paper, as it was one of the most essential things for protecting the stone Only that day he had noticed half-a-dozen masons trying to make a certain building in Holborn look like a new building: the face of the Portland stone had been made so hard by the quarry water that they could not get it off, and they could be seen chopping and hammering it in order to break that glassy surface It was a most distressing sight There was one other point he wished to mention. During the war he had had the duty of spending many hours in St Paul's Cathedral and he rather doubted whether the dirt on the face of the building was detrimental to the stone He thought that where Portland stone appeared white was where it had decayed, and where it was black and dirty it had not decayed If one were on the roof and there happened to be a shower of rain, the first water that came down over the roof and into the gutters was like milk, due to the face of the Portland stone being washed off Strong evidence that a single coat of paint was an excellent preservative for stone was provided by many tombstones he had seen which had been thus treated. He remembered one particularly, dated 1678, in Beccles churchyard. The inscription had had a single coat of paint put on it and although the face of the stone was worn away the inscription stood out quite clearly He thought that many coats of paint were not good, but if one thin coat of oil was applied to the stone it soaked into the stone and would give it a hundred years' extra life

Mr Noel Heaton, in reply, expressed his thanks to those who had taken part in the discussion and said that many of the points that had been raised would be of extreme practical value to all those interested in the subject, and especially to himself. He agreed with most of the Chairman's remarks and did not think his opinions were at variance with those of the Chairman except that variance which was essential to progress With regard to vegetation, for instance, they were really completely in accord. He did not in the least wish to convey that the presence of lichens on the stone was not a contributory cause of decay to some extent, but he did maintain that under

certain circumstances that decay was more than outbalanced by the advantages the lichens gave in the way of adding beauty to the stone and to a certain extent giving the stone resistance to certain forms of corrosion.

On the motion of the Chairman, a hearty vote of thanks was accorded to Mr Heaton for his interesting paper, and the meeting then terminated

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PROFESSOR CECIL H. DESCH, D Sc., Ph D., F.I.C., writes:—

After reading Mr Heaton's interesting account of the state of knowledge in regard to the preservation of stone, I find myself in almost complete agreement with him I would emphasise the statement that nothing is to be expected from secret processes. It is quite certain that no secret information exists as to preservatives of greater value than those of which the chemical character is quite well-known. My own experience is that the silicofluorides (this name is to be preferred to Fluosilicates, as having been adopted by the Chemical Society as a scientific name) afford better preservation than any other materials Treatment with wax has its advantages and may be used with care, but the actual hardening of the surface which is brought about by the chemical reaction between the silicofluorides and calcium carbonate causes a true hardening of the stone as well as a reduction of porosity When, however, the salts are applied in an unintelligent manner there is danger that a hard, impervious layer may be formed at the surface, which may scale when water gains access to the interior of the stone through joints. The object should be, not to render the surface completely impervious, but to reduce the porosity so far that destructive agents do not enter the stone, whilst leaving opportunity for slow evaporation of contained water There is no doubt that more careful treatment of the stone in quarrying, and in bedding correctly, would save much of the present trouble A most striking instance is that of Lincoln Cathedral, where the stone, carefully chosen from a good quarry, has preserved its texture most perfectly, so that the fine mason's marks are still quite clear The only change in the stone in this case has been a gradual solution and re-deposition of calcium carbonate which results in closing the pores. Unfortunately in modern town atmospheres this action is completely prevented by the presence of sulphur compounds, and chemical treatment is, therefore, called for. I am thus in agreement with Mr Heaton's conclusions with the exception of No. 4, for which I would substitute a recommendation of careful treatment with silicofluorides.

MR. H. O. WELLER, Director of Building Research, Scientific and Industrial Research Department, writes :—

I congratulate the author on his industry in putting together so many facts up to the present not connected, and on his careful analysis of these facts I am pleased to see that his conclusions agree with those I formed when initiating the research work which has been carried out by this Board during the last year, i.e., that all the work previously had merely resulted in more or less guarded confessions of failure by all disinterested investigators. The only exception was that the use of silicofluorides had been found effective in many instances. It seemed, therefore, the only line of advance to investigate the use of silicofluorides. Dr. Desch, of Sheffield, very kindly allowed us to be associated with the work he had started some years ago ; one investigator working under him has now worked out the proper salt to use, and the proper treatment with that salt for most of the best known building stones in the kingdom. The results will be published as soon as possible

I agree with the author in criticising the careless treatment of stone by many architects. There are bad examples in London and through the country of good stones used without regard either to sound tradition or to the discoveries of modern science. For instance, in the front of one well-known London hospital the ends of iron ornamental railings have been embedded in stone piers and sulphur run round them. The result is that the stone piers have been wrecked. In a new public building in the North of England, a local sand containing oil was used in the mortar ; the result is an oily stain spreading up into the stone from the mortar joints. Sound tradition would prohibit sand altogether. There has also been neglect of sound tradition in the building of stone war memorials up and down the country I know of two in one country town ; one in the market place, where a thin facing of limestone has been used as a retaining wall right up against damp sand ; the result being a pattern of hideous blotches of damp on the surface ; while worse results will probably follow as time goes on The other memorial, in the churchyard, has been to all appearances purposely designed to lead rain water falling on the upper part of the stone right across the inscribed panels The inscription will inevitably be torn out by the mere mechanical action of the rain within a few years.

OBITUARY.

RALPH BROCKLEBANK, J P., D.L.—Mr. Ralph Brocklebank, of Haughton Hall, Nantwich, died on the 19th inst., at the age of 81. He was born at Childwill Hall, Liverpool, and for many years was a partner in the well-known Brocklebank shipping firm. He was also Chairman of the locomotive committee of the London and North Western Railway.

His estate at Tarporley was regarded as one of the model estates of Cheshire

Mr. Brocklebank was elected a Fellow of the Royal Society of Arts in 1918. His name appeared in the recently published first list of contributors to the Fund for purchasing the Society's House, as a donor of £100.

THE MINERAL RESOURCES OF CZECHO-SLOVAKIA.

The deposits of iron ore in the Slovak country are very extensive. Two general regions may be distinguished, the Spis district and the district of the north-eastern Carpathians.

In the Spis district about 89 square kilometres of land are held by mining companies, an area equal to about 22,000 acres In 1917 this territory produced 1,215,500 metric tons (metric ton=2,204 pounds) of iron ore; in 1912, two years before the war, the yield was considerably larger - 1,529,430 metric tons The ore contains from 35 to 46 per cent of pure iron According to the most careful estimates of geologists, the mines of the Spis district still contain about 26,143,500 metric tons of ore, easily accessible, and an additional quantity of about 47,680,000 metric tons, also available but not so easily mined

The second district, that of the north-east Carpathians, is comparatively poor in iron ore, though mining operations are carried on there This region includes all those workings in the counties of Saris, Zemplin, Uzhorod, Bereg, Ugoca, and Marmaros In 1912 the production was 4,000 metric tons of the mineral The total capacity of the mines in this district is estimated at about 960,000 metric tons.

Hitherto, according to a report by the United States Assistant Trade Commissioner at Prague, the mines of Slovakia have been owned and exploited wholly by foreign capital Slovak labour was utilised in the actual working of the mining, but the great rewards went out of the country At first it was German capital which operated the mines of the Carpathians More recently this has given place to Hungarian capital At present the iron mines and some of the others are almost entirely in the hands of three companies, which have been combined to form one great trust.

The first of these was the Rimamuran-Salgotarjan Iron Co. ("Rimamurany-Salgo-Tarjani vasmu r t."), of Budapest. The second was the Hornad Valley Hungarian Iron Co ("Hernadvolgyi magyar vasipar r t."), also of Budapest. The third, called the "Union" Co., had its main offices in Vienna as well as in Budapest. The holdings of the two last-named companies have been long since acquired by the first, so that all three together now form a single enterprise

This trust owns large iron mines at Slovinky and at Horni Medzev The great lime and magnesite quarries, together with two lime-kilns, also belong to it. It owns blast furnaces at Likier and Hust and steel works at Salgotarjan and Ozd, outside of Slovakia. It employs altogether about 7,000 workmen and its machinery represents a total of 15,000 horse-power.

From 1915 to 1916, the forests on the lands belonging to the combine were extensively exploited About 50,000 cubic metres of lumber were sawn. In that same year 320,000 metric tons of iron ore were taken out of its mines, 120,000 metric tons of limestone, and 5,100 metric tons of magnesite, the last named solely for the company's own uses. Previous to the war, its blast furnaces worked day and night fron one end of the year to the other The blast furnaces of Likier and Hust turned out about 150,000 metric tons of pig iron per year.

The Hornad Valley Co., now a part of the trust, produced, in 1914, about 113,000 metric tons of iron ore, 74,000 metric tons of pig iron, 130,000 metric tons of steel, 30,000 metric tons of forged and 70,000 metric tons of rolled goods, as well as 2,000 metric tons of brass It worked 5 iron mines, from some of which copper was also taken, and 15 other concessions Its greatest foundries are at Krompachy, on the line of the Kosice-Bohumin Railway.

Slovakia is less favoured in the matter of coal deposits Its total coal resources have been estimated at about 1,717,700,000 metric tons. These deposits have scarcely been touched, inasmuch as coal mining in Slovakia only began about 10 years ago. The capital is entirely non-Slovak The largest coal mines are at Handlova, in the county of Nitra. They have been in operation since 1910. The coal is of excellent quality The future of these mines seems a bright one The mines at Jedlove Kostolany, near Zlate Moravce, are smaller and the workings are in bad condition The machinery needs thorough overhauling. There are also small but well-worked mines in Rapovce, near Lucenec.

The oil resources of Slovakia are undoubtedly one of the great assets of the Czecho-Slovak State. There are three basins, situated far apart, where oil is either flowing or is being prospected for

The first of the districts is that of Gbely, in the Morava basin, where the Austro-Hungarian Government began prospecting in 1912, and where about two tank cars of naphtha were extracted daily, yielding a very excellent quality of machine oil This same oil is now being used for the Czecho-Slovak State railways for lubricating purposes.

The second district is at Turzovka, in the county of Trencin. It has been recently reported that rich new oil wells have been discovered in this district. There seems to be a connection between these wells and those of Galicia. The prospecting in this district, interrupted by the war, is now being resumed with good results.

The third region is in the northern part of the county of Zemplin. English capital, as well as Hungarian, has been interested here. Prospecting has gone on in this part of the country almost up to the frontier of Galicia.

In addition to iron, coal, and oil, there are other minerals of considerable importance in manufacturing and the arts: Calciferous rocks for making lime and cement, sand for making glass, porcelain earth and kaolin, common salt, precious stones, opals, antimony, copper, manganese, cobalt, nickel, cinnabar, and pyrite. The antimony mines are especially valuable There are two deposits being worked, one in the county of Bratislava, near Pernek and Stupava, and the other in the county of Spis, near Smolnik and Gelnica.

The near future will probably see a more extensive exploitation of the mineral resources of Slovakia. It should also be remembered that, although there is not a very large supply of native coal to furnish motive power for industry, there are numerous excellent hydraulic sites along the streams flowing down from the Carpathians. The possibilities of water-power development, scarcely experimented with as yet, are unquestionably great in this part of Czecho-Slovakia.

The important deposits of magnesite in Slovakia, which from 1910 to 1913 formed the largest export from the former Austro-Hungarian Empire to the United States, are calculated to constitute about one-tenth of the world's total supply

THE PRODUCTION OF WOOD OIL IN CHINA.

One of the most important native products of China is wood oil. This oil is called nut oil in the United States, because it is expressed from a nut, but in China it is known as wood oil because it is chiefly used on wood. The demand for Chinese wood oil increased in a remarkable way during the war owing to the general increase of war industries in the Allied countries. The export of this commodity from Hankow has gone forward by leaps and bounds until it now stands second in rank of all commodities exported from this centre.

According to a report by the U.S. Vice-Consul at Hankow, wood oil is obtained from two varieties of *Aleurites*, a small genus of the spurge family. There are, Wilson states, *Aleurites montana* and *Aleurites fordii*. The former, or "mu yu," as the natives call it, is largely confined to southern China, while the latter, known as "tung yu shu," flourishes best in central and western China, where it is widely distributed. The "tung yu shu" is by far the more important of the two species and furnishes the major part of the wood oil which is exported from China.

Both species are hardy trees and grow luxuriantly in a hilly country up to an altitude of 2,500 feet. They seem to thrive in poor soil and are able to withstand long periods of drought; they are found as far north as 24° latitude, but in such a severe climate fail to bear fruit on account of the cold A full-grown tree is about 20 feet in height and the trunk measures 6 to 12 inches in diameter The "tung yu shu" tree is deciduous and sheds its leaves in October and November. It is low spreading, and in the spring produces a great profusion of white blossoms and flowers, the petals of which are sprinkled with pink and yellow. The fruit of the tree is about the size of a large walnut, in shape not unlike a persimmon with a smooth exterior and contains from 3 to 5 seeds When ripe the husk bursts open and the seeds or nuts fall to the ground.

The oil is generally bought up by dealers in cities or interior market places and held for speculation. It is with these dealers, or in some cases the mill owner, that the comprador of a foreign firm has to deal. When a shipment of wood oil has been purchased by the comprador it is placed on board a Chinese junk for trasnportation to Hankow Each junk holds from 300 to 700 baskets, which are lined with layers of varnished paper. En route the cargo is liable to taxation in various forms by the numerous military officers through whose territory it passes

Over 60 per cent of the wood oil entering Hankow comes from Szechwan or Kweichow and has to pass through the Yangtze gorges, where many cargo boats are wrecked Since the foreign manager in Hankow buys his wood oil from the comprador he prefers that the comprador take these risks, and consequently only pays for pure oil laid down in his godown at Hankow. Insurance rates on junks making the trip from Szechwan to Hankow are prohibitive. Some companies send small lighters into Hunan in order to tow cargo boats loaded with wood oil purchased in that Province Others buy their oil from Chinese dealers in Hankow who have bought cargo in the interior

Upon arrival at Hankow the wood oil is transported from the boat to the godown by coolies. In the godown the wood oil is usually allowed to settle for some time in the sun before the baskets are emptied The clear oil is weighed and strained into a pump which forces it into huge storage tanks. In the winter, when the oil solidifies, the basket is stripped off and the débris is removed by cutting the bottom of the cake off. After this it is necessary to heat the mass in order to allow precipitation to take place.

Each godown has one or several huge storage tanks, the capacity of which varies from 30 to 1,000 tons The bottoms of these tanks are conical, resting on a concrete foundation. They are tapped by faucets or cocks placed at various heights on the tank All the oil drawn off through the top faucet is sure to be pure. The impure oil and sediment are drawn off

through the lower cocks. The comprador of the firm is paid only for the pure wood oil. The débris and impure oil are weighed and sold for his account to local Chinese merchants, who in turn sell it to Chinese boatmen. A barrel factory is usually operated in connection with a wood-oil godown. The hoops and barrel staves are generally imported and set up in the factory. These barrels are usually made of oak and are said to be able to withstand four or five round trips between China and foreign countries. It is into these barrels that the refined product is poured ready for shipment. A barrel of wood oil weighs 450 pounds.

Wood oil is composed principally of the glycerides of oleic and elæomargaric acids and quickly becomes jellified when it is allowed to stand. Each firm has its own secret test for determining the purity of wood oil. When heated to 500° F. for a short time wood oil solidifies to a jellylike mass. This property forms the basis of the heat test for Chinese wood oil, which is very useful in determining its purity. On account of its high price it is often adulterated by the Chinese dealers. Many foreigners, inexperienced in the ways of Chinese sellers, have had sad experiences in connection with wood-oil purchases. Adulteration generally takes place when the market value is up, and soya bean, peanut, sesamum seed, and cotton seed oils are the usual adulterants.

The specification of the New York Produce Exchange in regard to wood oil is as follows:

Sec. 25. Pure China wood oil shall answer the accepted chemical requirements

Sec. 26. Commercially prime China wood oil shall be pale in colour (according to season's production), merchantably free from foots, dirt, and moisture. The total impurities shall not exceed 1 per cent.; but, unless otherwise provided for, impurities not plainly adulterations, up to 5 per cent. shall not justify rejection, but allowance shall be made by sellers for such impurities in excess of 1 per cent. The oil shall stand the heat test, herewith subjoined:

Heat or coagulation test for China wood oil.—One hundred grammes of the oil is heated in an open metal pan, 6 inches in diameter, as rapidly as possible, to a temperature of 540° F. The time required to heat the oil from room temperature to 540° should be, as nearly as possible, the same each time, four minutes being usually sufficient with gas burners. Hold the oil at or as near to 540° as possible, stirring until it begins to solidify. Note the time required after the oil reaches 540° and until it begins to solidify. This should not exceed seven and one-half minutes for any commercially prime wood oil. When the oil has solidified in the pan, turn it out while still hot and cut with a knife. Commercially prime wood oil gives a product that is pale, firm and cuts under the knife like dry bread, not sticking. If the oil requires more than seven and one-half minutes after reaching 540° until beginning to solidify, or if the product is dark, soft or sticky, the oil may be rejected.

Other heat tests used by local business men are Bacon's, Browne's, and the Pratt and Lambert tests.

The heat tests, together with the determination of the specific gravity, iodine number, saponification number, refractive index, etc., usually determine the purity of Chinese wood oil.

China wood oil is largely used as a substitute for linseed oil, varnish, linoleum, and paint, because of its rapid drying properties. The Chinese have many uses for wood oil, the most important of which is as a preservative for the thousands of boats that ply on China's inland waterways. The Chinese junkman never paints his boat but coats it with the cruder grades of wood oil; this not only gives the woodwork a bright lustre but acts as a preservative. The residue of the wood oil nut after the oil has been extracted is sometimes burned to a soot, which is mixed with oil to make a paste for caulking boats. Another combination used by the Chinese boatman for caulking purposes is a mixture of the oil with lime and bamboo shavings. Wood oil is also used as a dressing for leather, as varnish for furniture, in soap making, and in making lacquer.

The native combines certain mineral substances with wood oil, and by cooking the mixture produces a substance known as "kwangyu," which is used by the Chinese in waterproofing the paper employed in the manufacture of Chinese umbrellas The oil is also used by the natives for waterproofing cloth shoes, silk, pongees, and other materials. By means of this substitute the Chinese have managed in a remarkable way to get along without the use of rubber. The best grades of Chinese ink are obtained by burning the oil or husks from wood oil nuts. The residue of the nut, like the oil, is poisonous and is used chiefly as a fertiliser.

The price of wood oil, like any other commodity, determines to a large extent the quantity exported in any one year. The demand from foreign countries continues to increase. The quantity available for export depends upon political conditions in the interior, and these in turn react on local prices. It often happens that certain producing regions are practically cut off by the presence of bandits in those particular localities.

The total quantity of wood oil exported from China to foreign countries during the years 1912-1920 was as follows:—

Years.	Pounds.	Years.	Pounds.
1912......	77,708,400	1916......	68,689,600
1913......	61,819,600	1917......	53,514,800
1914......	58,515,600	1918......	65,180,000
1915......	41,379,200	1919......	81,794,000
		1920......	72,095,600

It is understood that successful attempts have been made to grow the wood oil nut in some parts of the United States. In China the farmer receives no help of any kind from the Government. To further the continued growth of this promising industry in China, adds the United States Vice-Consul, Government aid is urgently needed. In his opinion nurseries should be established where tree selection can be carried out for the benefit of the grower, and farmers should be taught a uniform method of picking the fruit, upon which depends to a large extent the amount of oil obtained from the nut. The present crude methods of crushing the nut result in a great amount of waste. If the Chinese could be induced to instal modern machinery in place of the native presses now in use, the Vice-Consul thinks it would mean a saving of 10 per cent. or more

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

January 18.—Julian S. Huxley, M.A., Fellow of New College, Oxford, "The Control of Sex in Animals."

January 25.—Howard Maurice Edmunds, "Photo-Sculpture."

February 1.—Arthur Wilcock, "Surface Printing by Rollers in the Cotton Industry."

February 8.—Edward Victor Evans, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry." Sir Arthur Duckham, K.C.B., M.Inst.C.E., in the chair.

February 15.—Cloudesley Brereton, M.A., Divisional Inspector to the London County Council (Modern Languages), "The Necessity of Speech Training, and the Need of a National Conservatoire."

February 22.—Alexander Scott, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum."

March 1.—Emanuel Moor.

March 8.—W. A. Appleton, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions." John Murray, M.P., in the chair.

March 15.—Oswald T. Falk, "Certain Aspects of the Problem of Exchange Stabilisation." Sir Robert M. Kindersley, K.B.E., in the chair.

March 22.—Principal A. P. Laurie, M.A., D.Sc., F.R.S.E., "Permanency of Oil Colours."

March 29.—Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.)

Dates to be hereafter announced:—

Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

John Francis Crowley, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry."

George Fletcher, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

Professor Ernest R. Matthews, "Sea Encroachment and its Prevention."

Philip Schidrowitz, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

Indian Section.

Friday afternoons at 4.30 o'clock.

January 27.—Alexander L. Howard, "The Timbers of India and Burma." The Right Hon. E. S. Montagu, M.P., Secretary of State for India, in the chair.

March 24.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India."

April 28.—F. G. Royal-Dawson, M.Inst.C.E., "The Need for an All-India Gauge Policy." Sir Robert Woodburn Gillan, K.C.S.I., LL.B., in the chair.

May 26.—Professor Sir Thomas W. Arnold, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.)

Date to be hereafter announced:—

J. T. Marten, I.C.S., M.A., "The Indian Census."

Dominions and Colonies Section.

Tuesday afternoon, at 4.30 o'clock.

March 7.—Major Sir Humphrey Leggett, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

Date to be hereafter announced:—

LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "Queensland."

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETING.)

Friday afternoon, at 4.30 o'clock.

FEBRUARY 24.—PROFESSOR WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., "Brown Coals and Lignites: Their Importance to the Empire."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." Three Lectures.

Syllabus.

LECTURE I.—JANUARY 23.—Historical Introduction—Nature of Inks—Egyptian and Chinese Inks—Modern Carbon Inks—Sepia—Iron Gall Writing Inks—Methods of Preparation Properties—Iron Tannates.

LECTURE II.—JANUARY 30.—Logwood Inks—Vanadium Inks—Aniline Inks—Coloured Writing Inks—Examination of Writing Inks—Characteristics of Ink in Writing—Copying Inks

LECTURE III.—FEBRUARY 6.—Marking Inks—Printing Inks—Preparation of Lamp Black—Carbon Blacks—Boiled Oils—Typing Ink—Inks for Miscellaneous Purposes—Secret Writing.

ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." Three Lectures.

Syllabus.

LECTURE I.—FEBRUARY 20.—Design from the point of view of the User and the Manufacturer—Clerk Maxwell's axioms of Instrument Design—Degrees of Freedom and Constraint—The Six Degrees of Freedom of a Rigid Body—Geometric Design.

LECTURE II.—FEBRUARY 27.—The Lower and Higher Pairs—Restraint against Sliding—Restraint against Rotation—Centrodes and Axodes—The Design of Profiles.

LECTURE III.—MARCH 6.—The Elastic Nature of all Materials—The Elastic Constants—The Rigidity of Instruments—Manufacture—Models—Interchangeable Manufacture.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

COBB LECTURES.

Monday evenings, at 8 o'clock.

F. F. RENWICK, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MANN JUVENILE LECTURES.

Wednesday afternoons, January 4 and 11, at 3 o'clock.

WILLIAM REGINALD ORMANDY, D.Sc., "Clay: What it is—Where it comes from—and What can be done with it."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, JAN 2 . Architectural Association, 34, Bedford Square, W.C., 8 p.m. Mr H. S Goodhart-Rendel "Classic Architecture in England (1650-1850); its story and its Teaching"
Geographical Society, 135, New Bond Street, W., 3 30 p m (Juvenile Lecture) Miss Ella Sykes, "A Ride on the Roof of the World."

TUESDAY, JAN 3 Royal Institution, Albemarle Street, W. 3 p.m (Juvenile Lecture) Prof. J. A. Fleming, "Electric Waves and Wireless Telephony." (Lecture III)
Automobile Engineers, Chamber of Commerce, Birmingham, 7 p.m. Mr. W. W Hackett, "Experiments with Weldless Steel Tubing as used in Construction."
Photographic Society, 35, Russell Square, W.C., 7 p m

WEDNESDAY, JAN 4 . Geological Society, Burlington House, Piccadilly, W, 5 30 p.m.
Electrical Engineers, Institution of, Victoria Embankment, W.C, 6 p.m. (Wireless Section). Lt-Col. A. G. T. Cusins, "High Speed Wireless Telegraphy."
Colonial Institute, Hotel Victoria, Northumberland Avenue, W C, 3 p m. (Juvenile Lecture) Miss E M. B. Warren, "Through the Land of the Maple Leaf."

THURSDAY, JAN. 5 . Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C, 5 30 p.m. Wing Commander W. D Beatty, "Specialised Aircraft."
Royal Institution, Albemarle Street, W., 3 p.m. (Juvenile Lecture). Prof. J. A. Fleming, "Electric Waves and Wireless Telephony." (Lecture IV.)
Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Dr. S. Parker Smith, "Single and Three-Phase Commutator Motors with Shunt and Series Characteristics."

FRIDAY, JAN 6 . Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. "The Co-operation of the Engineer and Chemist in the Control of Plants and Processes." (Joint Meeting with the Society of Chemical Industry.)
Geographical Society, 135, New Bond Street W. 3.30 p.m. The President, "Pictures from Mount Everest."
Chemical Industry, Society of (Manchester Section), Joint Meeting with the Institute of Chemistry, Society of Dyers and Colourists, and Manchester Literary and Philosophical Society) at the Textile Institute, 16, St. Mary's Parsonage, Manchester, 7 p.m. Prof. A. Harden, "Biochemical Method."

SATURDAY, JAN. 7 . Royal Institution, Albemarle Street, W., 3. p.m. (Juvenile Lecture). Prof. J. A. Fleming, "Electric Waves and Wireless Telegraphy. (Lecture V.)

Journal of the Royal Society of Arts.

No. 3,607 VOL. LXX.

FRIDAY, JANUARY 6, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W C (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 11th, at 3 p.m. (Juvenile Lecture.) * WILLIAM REGINALD ORMANDY, D.Sc., F.I.C., "Clay: What it is—Where it comes from and What can be done with it."

"OWEN JONES" AND "MULREADY" PRIZES

The Council of the Royal Society of Arts hold a sum of £400, the balance of the subscriptions to the Owen Jones Memorial Fund, presented to them by the Committee of that fund in 1876, on condition that the interest thereof be spent in Prizes to "Students of Schools of Art, who, in annual competition, produce the best designs for Household Furniture, Carpets, Wall-papers and Hangings, Damasks, Chintzes, etc., regulated by the principles laid down by Owen Jones."

The Council offer six Prizes in 1922, for the following subjects:

ARCHITECTURAL DECORATION: Including Stained Glass, Mosaic for Walls and Floors, Plasterwork in relief and incised, Inlaid Marble and Stones, Lettering for Memorials.

WOODWORK AND CABINET WORK: Including Carving in Wood, Ivory and Bone, Inlay, Chairs, Chests, Cabinets.

TEXTILES*: Including Tapestries, Carpets and Rugs, Moquettes, Floor-coverings (*e.g.* Linoleums and Floor-cloths).

Each Prize will consist of the Society's Bronze Medal and a copy of a book or books on Applied Art, of a value not exceeding £2, to be selected by the successful competitor.

In addition to the above prizes, A SPECIAL PRIZE OF TWENTY POUNDS is offered, under the Mulready Trust, for the best design (irrespective of class) submitted for competition.

The Council reserve the right of withholding any or all of the Prizes offered, and they will be the sole judges in each individual case of the qualifications of a competitor to receive an award.

The competition is limited to Students of Schools of Art.

Competing designs must be sent, carriage paid, and labelled "Owen Jones Prize Competition" on the outside, to

THE DIRECTOR AND SECRETARY,
Victoria and Albert Museum,
South Kensington, S.W. 7.

between June 12th and June 17th, 1922.

They may be delivered by hand on any of the three days ending June 17th.

The sender must also notify the Secretary of the Royal Society of Arts by post that the design has been sent in, and must enclose stamps or P.O.O. for the return carriage.

The awards will be made by the Council of the Royal Society of Arts on the recommendation of Judges appointed by them.

Arrangements will be made, if possible, for the public Exhibition of the competing designs in the Victoria and Albert Museum, South Kensington, as in previous years.

All possible care will be taken of the designs, but the Council accept no responsibility for injury or loss.

* It should be noted that only the classes of Textiles mentioned above are eligible in 1922.

CASES FOR JOURNALS.

Cases for keeping the current numbers of the *Journal* are now obtainable. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s.* 6*d.* each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, DECEMBER 6th, 1921.

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., G.C.M.G., G.C.V.O., LL.D., Governor-General of Canada, 1916-1921, in the chair.

THE CHAIRMAN said his task that evening was a very simple and pleasant one, namely, to introduce Mr. Wade, the Agent-General for British Columbia, who was to deliver a lecture on the subject of that very great and beautiful country. He did not think he should be giving any wrong advice if he advised all who had not yet seen the country to take an opportunity of doing so. It was a country which personally he had the greatest sympathy, regard and affection for, not merely on account of its wonderful natural assets and its great scenery but for the splendid character and robustness of its inhabitants. In the earlier stages of the war, in 1914, he believed the great province of British Columbia suffered to a large extent. There was no waiting there—all classes of the population at once flocked to the colours and the record of service and work done by that Province was one which at all times would be memorable in its history. He knew that those present were most anxious to hear the lecture and he therefore had the greatest pleasure in introducing Mr. Wade.

BRITISH COLUMBIA: THE AWAKENING OF THE PACIFIC.

BY FREDERICK COATE WADE, B.A., K.C.,
Agent-General for British Columbia

Columbus did not know that he had discovered America. When the cannon shot from the Pinta on the night of October 12th, 1492, proclaimed land in sight, he was convinced that he had at last reached the islands on the coast of India. Hence, St. Salvador and the rest of the Islands became the West Indies. When on his fourth voyage, ten years afterwards, he reached Darien (now Panama) he believed he was on the Continent of Asia. The aboriginals of America were, therefore, called Indians. Strange to say, he thought he could reach the East Indies through the Isthmus of Darien (which we now do) and tried to do so, but without success. He died quite ignorant of the responsibility he had incurred in discovering America.

Unless Balboa had been hopelessly in debt, it is impossible to tell when the Pacific Ocean would have been found out. Having failed as a planter in Haiti, to escape his creditors he hid in an empty cask, and became part of a ship's cargo on the way to the mainland of South America. On September 25th, 1513, from the summit of a mountain at a point opposite the Gulf of Miguel he beheld the Mar del Sur (the Southern Sea), seven years later to be visited by Magellan and named the Pacific Sea. On September 28th Balboa took formal possession of the Southern Sea, by marching into the waters and claiming both seas and land in the name of the King and Queen of Castile. The people of the Pacific are deeply indebted to the creditors of Balboa, who four hundred years ago chased him into a hollow cask and started him on his momentous mission.

Balboa had heard of the silver mines of Peru and of her civilisation. Columbus probably had found out a good deal at Darien. No wonder that, like Alice, they were all anxious to get behind the looking-glass, and to some extent Balboa and Magellan succeeded.

From the time of Columbus up to the memorable voyage of Captain Cook, and even later, the attempt to discover the Straits of Anian or the North West passage through the continental mass of America to India led to a series of voyages—Spanish, Portuguese, Russian, British, French and American—full of adventure, hardship and romantic daring and worthy of the best traditions of the human race. On the Atlantic side Cabot, Cortereal, Frobisher, Baffin, Hudson, on the Pacific, Cortes, Pizarro, Maldonado, Mono de Guzman, Juan de Fuca, Dechenev, Baring, Tchirikoff, Drake, Cook and Vancouver, Kendrick and Gray, nosed their ships' prows along the shores of both oceans looking for the mythical Straits of Anian, the supposed short and direct route through the continent to and from India. It is interesting to know that in one of these voyages Frobisher named Greenland West England and the last cliff he sighted on leaving, he called "Charing Cross." There is a point on the east side of Newfoundland I believe, called Piccadilly, an irreverent Cockney sailor's corruption of Pic St. Denis.

The passage was never found. Someone has said that if no Sabbath had been ordained, it would be necessary to create one. The solution came with the building of the Panama Canal. It is interesting to note that the building of a canal across

the Isthmus had been urged on the attention of the King of Spain by Galvao, a Portuguese navigator in 1520, but for political reasons the project was suppressed and the death penalty attached to any attempt to re-open the matter.

From 1608 to 1768 the north-west coasts of North America were entirely neglected. In 1763 Canada was added to Great Britain. But the distance by Cape Horn from Liverpool to the coast which is now British Columbia was 14,558 miles, as against 2,456 miles to Halifax on the Atlantic. It was this difference in distance whch caused the lop-sided development of the American Continent, the early occupation of the Atlantic Coast as against the retarded settlement of the coasts of the Pacific. Had the Straits of Anian been a fact instead of a myth, or had Antonio Galvao in 1550 succeeded in having a canal built through the Isthmus of Darien to reach the sub-tropical coasts of the Pacific, settlement on the Pacific Coast would have kept pace with that on the Atlantic. Some malicious Westerners say that the charms of the Pacific are so superior to those of the Atlantic Coast that if the race had been an even one, the Atlantic Coast would not have been settled yet.

The cutting of the Panama Canal has reduced the distance from Liverpool to Victoria, British Columbia, from 14,558 miles to 8,512. The distance by land and sea from Vancouver to Liverpool *via* Montreal is about 5,852 miles as against 8,512 miles by the Panama Canal, the all-sea route. The difference between the old all-sea route ' round Cape Horn and the trans-continental and Atlantic route was 8,706 miles. The difference between the all-sea route by the Panama Canal and that *via* Montreal and the Atlantic is only 2,660 miles. The disadvantage in distance by sea as against that over land and sea has been lessened more than two thirds, if it does not approximate to three-fourths. What this means to commerce and civilisation in and around the Pacific can scarcely be conjectured. The discovery of America by Columbus has been described as "the God-like gift to humanity of half a world." The opening of the Panama Canal is the gift of the other half.

It is too soon to make a comparison of freight rates from the Pacific Coast and Central Canada to Europe *via* the Panama Canal with the rates across the Continent and *via* the Atlantic. Traffic by the new route is only in its inception and rates have not become stabilised. It can be pointed out, however, that the Vancouver route embraces a much larger proportion of water mileage, that it is on the water that the greatest competition exists, and consequently the greatest tendency to shrinkage in rates. As an instance of what water carriage means as against land carriage, take Regina, situated almost the same distance from Halifax, as Halifax is from Liverpool. The shipment of a quarter of wheat from Regina to Liverpool costs, say, 21s., but of this total only 4s. represents water carriage, while 17s. represents land carriage, though the distances in each case are practically the same.

The Great War has produced several new factors which profoundly affect the whole position of the railroad and grain interests in the Dominion:

1. Great increase in the cost of rail haulage.
2. Great expansion of ocean tonnage.
3. The availability of some of this tonnage to provide new services for the west coast of Canada at rates based upon the highly competitive nature of sea transport under peace conditions.

Another important factor to be considered is the revolution in transportation by the introduction of the motor boat with Diesel engines using oil for fuel. It is unquestionably the fact that the Swedish line of motor freighters of the North Star or Johnson line now operating out of Vancouver through the Panama Canal is run at a considerable saving on the cost of steam transportation. Grain is transported to Europe by the cheapest of all kinds of transport (namely, by all water, or almost all water) from the Argentine, Australasia, East Mediterranean, India, etc., and it is no rash prophesy to say that before long the great bulk of the grain of Western Canada will adopt the sea route as well. Indeed, the movement is already in full swing. On February 9th, 1921, the Buenos Aires of the North Star or Johnson line of Stockholm brought the first direct commercial shipment of Canadian wheat (3,200 tons) from Vancouver to London. It was No. 2 Northern Manitoba wheat, and arrived in perfect condition. During the fiscal year ending June 30th, 1921, there were sailings through the Canal from British Columbia to the United Kingdom and Northern

Europe, to the Atlantic and Gulf Coast of the United States, to Mexico, the Mediterranean, Cuba, the East Coast of South America, and Eastern Canada, and of these 20 cargoes, aggregating 138,435 tons, were bound to the United Kingdom and Northern Europe alone.

In considering the extent to which the wheat of Western Canada will be routed to Europe *via* Panama, it is important to remember how much nearer the wheat centres of Western Canada are to the Pacific than to the Atlantic Sea board. The following is a table of distances from some of the principal cities in the great western Provinces, Manitoba, Saskatchewan and Alberta to Vancouver, Montreal and Halifax respectively :—

	Miles from Vancouver.	Montreal.	Halifax.
Brandon ..	1477	1507	2348
Regina	1256	1727	2568
Saskatoon ..	1096	1842	2693
Battleford ..	1025	1983	2824
Edmonton ..	770	2167	3003

Brandon in Central Manitoba is 30 miles nearer to Vancouver than to Montreal and 871 miles nearer Vancouver than to Halifax. Regina in Saskatchewan is 471 miles nearer to Vancouver than to Montreal, and 1,312 miles nearer to Vancouver than to Halifax. Edmonton in Alberta is 1,397 miles nearer Vancouver than she is to Montreal and 2,238 miles nearer to Vancouver than to Halifax. It is obvious that the rail haul is much shorter to the Pacific than to either Montreal or the Atlantic from most points in Western Canada. Just as, the Great Divide marks the point where the great rivers of the west have their common source and then separate to flow east and west, there is a Great Economic Divide between conditions and distances which will determine how much of the product of Central and Western Canada will be carried east and west respectively. Whether that point is Regina or Moose Jaw remains to be determined.

But there are even other important factors to consider. The great inland water-ways of Canada are available only in the summer months. Montreal is not available as a port after the close of navigation. Vancouver and Prince Rupert and the whole coast line of British Columbia are open throughout the year. Not only are the ports open but there is not a day in the year when the weather is cold enough to interfere with work.

Another serious factor which alone will force the adoption of the western route for moving a great part of the crop is the danger of freight congestion, and shortage of cars in the east. Last August, when a serious congestion was more than threatened in Montreal, the Winnipeg correspondent of the Vancouver Province said :—

"Exporters here state it is most important that at least 75,000,000 bushels "of the export surplus should be got out "before the close of navigation, but are "pessimistic as to how it is to be done. "It is of the first importance to all business "interests that half the export surplus "be turned into cash as speedily "as possible. A tie-up of the grain "movement means great inconvenience "and in some cases disaster.

"The real solution is the utilisation of "the alternative Pacific Coast route. "It is logical that all grain west of Moose "Jaw go that way and no time should "be lost in organising the movement "and the trade. The West has a moderate "crop, some 200,000,000 for export, "yet there is trouble ahead in its transportation. Had it been a bumper year "with 300,000,000 to sell, existing difficulties would have been greatly accentuated."

How many of us have any idea of the causes which go to make up congestion in traffic in Western Canada? Taking the cereal crop of Canada for 1921 as 288,493,000 bushels, we have 288,493 carloads at 1,000 bushels to the car, which divided into trains of 20 cars each, will give us 14,449 trains of cars loaded with grain. At 53 feet to the car we would have five trains to the mile or a single train 2,889 miles in length. As there are only 365 days in the year, if the entire crop had to be handled through Montreal on a single track, it would be at the rate of about 40 trains a day or nearly two every hour. As there are still 37 million acres in easy reach of the railways in Western Canada, and hundreds of millions as yet untouched and which yet have to be developed, the folly of handling the crops of the future, not to speak of the present, overland and by only one ocean route can easily be realised.

Assuming, then, that the export traffic of Canada in the future will move west as well as east, there is an important point

to consider which is bound to affect immensely the development of the West as against the East, and in the end develop our Pacific ports to an extent as yet undreamt of. It has been estimated that the arable land of what may be called Pacific or Western Canada comprises 333,000,000 acres as against 160,000,000 in Eastern or Atlantic Canada. On this basis it is evident that with the development of traffic westwards and *via* the Panama Canal, the products and traffic of Pacific Canada may double that of Atlantic Canada. This is one of the results to be expected from the awakening of the Pacific.

Let me at this stage give some idea of the awakening process as it has already become very evident in British Columbia. It was on the 7th November, 1885, at the little station of Craigellachie in the Eagle Pass in the Gold Range, in British Columbia, that the rails from the Atlantic met those from the Pacific, and the last spike was driven by Donald Alexander Smith, afterwards Lord Strathcona. As the hammer strokes fell those present felt that they were witnessing the crowning act in the creation of the Canadian Confederation and the welding together of a new nation. Queen Victoria cabled her congratulations to the Canadian Pacific Railway on the completion of a work "of great importance to the British Empire." It was that, and much more. It was the completion of the north west passage by land, just as the Panama Canal is its completion by water, and a world event of the very first importance.

Although not two score years have elapsed since the echoes of Donald Smith's hammer were heard in the narrow gorge at Craigellachie, there are now many great transcontinental railways with terminals at Vancouver, and ocean steamship lines to all parts of the world.

Vancouver and Victoria are served by both the Canadian National and Canadian Pacific Railways; the Northern Railway from Washington; the Great Northern, Northern Pacific, Chicago, Milwaukee and St. Paul; Union Pacific, Pacific Great Eastern, and a number of other American lines. Practically all ocean steamship lines operating on the Pacific use the ports of Vancouver and Victoria. These lines include the Atlantic Line to California; the Blue Funnel Line to Japan and China, and *via* the Panama Canal to London and Liverpool; the Border Line Transportation Company to the State of Washington; the Canadian-Australasian Royal Mail line to Honolulu, New Zealand and Australia; the Canadian Government Merchant Marine, Ltd., to Australia, New Zealand, India, China and Japan; the Canadian Pacific Steamships, Ltd., to Japan, China, Washington, Prince Rupert and Alaska; the Royal Mail Holland-America Service and the Furness Prince Service both running to the United Kingdom and the Continent; the Canadian Robert Dollar Steamship Co. to China, Manila and Singapore; the "Harrison Direct" line to Seattle, San Francisco, Los Angeles, *via* the Panama Canal to Liverpool, London and Glasgow; the Johnson line to France, the United Kingdom and Stockholm; the Isthmian Steamship line from the Pacific Coast ports to New York and the United Kingdom; the Osaka Shosen Kaisha line to Japan, China, Vladivostok, Singapore and Bombay; the Pacific Steamship Company to Californian and Alaskan ports; the Union Steamship Co. to British Columbia and Alaska; the Société Générale de Transports Maritimes to the Mediterranean; and, from Victoria only, the Nippon Yusan Kaisha Line to Japan, China and Manila. There are now 34 regular deep-sea shipping lines operating into Vancouver as compared with 12 in 1914.

Esquimalt, close to Victoria, and Prince Rupert, the Pacific terminus of the Canadian National Railway, are becoming of greater importance yearly.

There has been a great increase in the shipping activity of the Port of Vancouver during the past year or so. The Canadian Pacific Railway Company has established the passenger and freight liners, the "Empress of Russia" and "Empress of Asia"; the "Empress of Canada" will leave the Clyde for her Pacific Station in February, to be followed by the "Empress of Australia." These are amongst the first steamships in the world. Similarly the Canadian Government Merchant Marine, Ltd., have instituted important new services. Besides inaugurating regular services to Japan, China, New Zealand and Australia, they have despatched the "Canadian Prospector" and "Canadian Traveller," with mammoth cargoes of timber to Egypt, India and South Africa.

For the fiscal year ending March 31st, 1918, the number of sea-going vessels outwards and inwards, and of coasting vessels outwards and inwards at Vancouver, was 22,985 with a total registered tonnage of 10,890,748

tons. In 1900 only 3,441 vessels of 13,699,238 tons gross measurement passed through the Suez Canal A comparison of these figures will give some idea of the vast development of shipping and trade on the Pacific Coast since the Canadian Pacific Railway inaugurated its trans-Pacific line in 1887

When it is considered that the last spike in the rails connecting Vancouver with Eastern Canada was driven by Lord Strathcona at Craigellachie in 1885, and that the site of Vancouver was an almost unbroken forest as late as 1885, and that the Canadian Pacific directorate did not decide to inaugurate its trans-Pacific services to China and Japan till 1891, only thirty years ago, it cannot be long before Vancouver becomes the Liverpool of the Pacific and Victoria and Prince Rupert great ocean ports.

One of the most remarkable developments on the Pacific Coast within the last few years has been in shipbuilding. Prior to 1917—only four years ago—not a single ocean-going ship had been built in British Columbia. By January, 1920, 90 wooden ships, 40 of them for the French Government, had been constructed, with a total tonnage of 217,900 tons, and 31 steel steamers of 207,900 dead-weight tons, a total of 121 ships of 425,800 dead-weight tons, had been constructed, and a number have been launched from the ways during the last year. The total already reached is 600,000 tons.

Pulp and paper manufacture was not established on a commercial basis till 1912. Since then seven pulp mills have been established. British Columbia already ranks third in this industry amongst the Provinces of Canada. The output for 1919 was sulphite, 8,047 tons; sulphate, 9,473 tons; ground wood, 99,769 tons; paper and news-print, 123,607, and wrapping paper 7,202 tons. She possesses 300,000,000 cords of spruce and other pulp woods, the largest stand of pulpwood in the world, with water powers near ocean navigation. In a very short time British Columbia must rank first among the Provinces of Canada as a pulp and paper producer.

Until 1897 the famous Okanagan was a land of bull pines and sage brush. Irrigation was introduced and the first orchard in the district set out that year. This season British Columbia has produced 3,027,000 boxes of apples. British Columbia fruit won its first gold medal at the Royal Horticultural Show in London in 1904. She also carried off the gold medals in 1906, '7, '8, and '10, and in 1910 won the highest fruit prize in the Empire, the Hogg Memorial Gold Medal. At the Imperial Fruit Show just closed she won seventeen medals, or more than all the other Provinces of Canada combined.

Salmon canning as a business was first undertaken on the Fraser River in 1870. The largest pack of salmon in British Columbia was in 1918, when the total of all species was 1,616,157 cases. This represented 17,777,727 fish on a basis of 11 fish to the case; in pounds 78,575,536, the standard weight of fish in a case being 48 pounds net. The production of fish in 1919 was 44.7 per cent. of all Canada.

British Columbia is the western front of the British Empire on the Pacific Ocean, and I have referred to several evidences of the awakening processes going on there. But the awakening of the Pacific means much more than the activities of any one country. It is the awakening of the world's great giant. Gulliver, when he visited Brobdingnag, the country of gigantic giants, found that he was a pigmy "not half so big as a round little worm plucked from the lazy finger of a maid." The Pacific Ocean doubles the Atlantic in area. With the Indian Ocean and its tributary seas it more than trebles the Atlantic area. It exceeds in compass the whole of the four continents. On its shores and innumerable islands dwell two-thirds of all mankind. There lies the Imperial Pacific Dominion with nine-tenths of British possessions. There is not a settlement, no matter how remote, in the great Pacific world but feels to-day the heart throb of new and vigorous life. Japan, India, China, Australia, New Zealand, Oceania, South America, the United States, Canada—all are pulsing with new life and enterprise, and actuated by high aspirations and great hopes, due in no small degree to the opening of the Panama Canal. In April last it was predicted in the Canadian House of Commons that before two years the commercial and political centre of the world would pass from the Atlantic to the Pacific. It is already the centre of world politics. How long will it be before it becomes the centre of the world's commerce before British Columbia becomes the imposing entrance portal of Canada, instead of what it was at one time, its postern gate?

What part is British Columbia to play in the great awakening which has already begun, in the most momentous event of the twentieth century? The whole answer depends upon the resources which she is able to contribute to this giant development, particularly upon the stores of energy which she is able to employ. The list of these is formidable:—

Timber. 400 billion feet.

Coal. 75 billion metric tons.

Waterpower. Total for ordinary minimum flow, 1,931,142 horse-power; maximum development dependable for six months, 5,103,460 horse-power.

Iron. Magnetite equal to best Swedish ore, and hematite of best grade, estimated three million tons.

Some of the staple-products are:—

Agriculture, 1919	$61,000,000
Forest, 1919	$70,000,000
Minerals, 1918	$41,782,474
Fish, 1917	$21,518,595
Total Mineral product, including 1918	$637,358,581

Last, but by no means least, climate and sunshine. Vancouver Island has been called the "Madeira of the Pacific." British Columbia is the Riviera of Canada.

It lies between parallels of latitude 49° and 60°, where the best things grow. The Japanese current, the mountain barriers against the East and West winds, and the ocean tides of the Pacific produce an unequalled climate.

The average temperature in the coldest month (January) is 39° Fahr. at Victoria. The average temperature in the warmest month (July or August) is remarkably cool—60° at Victoria. Bright sunshine on the coast is 2,068 hours, or more than in Great Britain or even the Channel Islands.

As Captain Vancouver said 140 years ago:—

"To describe the beauties of this region will, on some future occasion, be a very grateful task to the pen of the skilful panegyrist. The serenity of the climate, the innumerable pleasing landscapes, and the abundant fertility that unassisted Nature puts forth, require only to be enriched by the industry of man with villages, mansions, cottages, and other buildings to render it the MOST LOVELY COUNTRY THAT CAN BE IMAGINED, whilst the labour of the inhabitants would be amply rewarded in the bounties which Nature seems ready to bestow on cultivation."

(Following the paper several series of cinematograph views were exhibited.)

The Chairman (the Duke of Devonshire), wished, on behalf of those present, to thank the author very deeply and sincerely for the admirable paper and illustrations. They recalled to him many interesting and happy memories. One point he wished to lay emphasis upon was the fact that only about a third of the country had been yet touched at all. The figures Mr. Wade had given were very striking but there was much within the region which had not been explored in Vancouver Island for example. The great district of the Peace River was only just opened, and when that was connected with the coast it would add enormously to the knowledge possessed at the present time. When he saw on the film that absolutely marvellous timber being smashed up to be made into newspapers it filled him with horror. Newspapers he supposed were necessary or desirable, but still he thought a better fate should await some of that beautiful timber. Wonderful as had been the progress in a short time, the next 10 to 25 years were going to see still more marvellous development and the contribution Mr. Wade had made that afternoon would stimulate great interest in the subject. He was sorry that owing to a prior engagement he would have to vacate the chair and leave the meeting.

The chair was occupied for the remainder of the meeting by Sir George R. Parkin, K.C.M.G., LL.D., D.C.L.

DISCUSSION.

Sir George Parkin, K.C.M.G., LL.D., D.C.L., said he thought it was very valuable that the people of this country should have their imagination stretched to understand the amazing changes which were taking place in different parts of the Empire. The vivid way in which Mr. Wade had put forward his facts must have impressed everyone. He should like to add to what the author had said something about the extraordinary national importance of the things which were happening on the Pacific Coast. The author naturally, as representing British Columbia, had brought forward the resources of that country, but it was necessary to understand also the great importance of it to Great Britain. The author had referred to the lop-sided development of the American Continent. He (Sir George Parkin) should like to dwell as a Canadian on the kind of energy which was thrown into correcting that lop-sided development. A little before the year 1886, when the Canadian Pacific Railway was started towards the West, there was practically more than 2,000 miles of country without any civilised population whatever with the exception of one or two small towns. America a few years before had built

a railway across the Continent. There were 20 million people on one side of the Continent and 2 million on the other, before America dared to face that problem, and yet Canada faced it when there were only 3½ millions on the East and only 50,000 in British Columbia. That gigantic task of crossing the uninhabited country was faced in order to open up a connection. The man whose pluck and energy had more to do with it than anyone else was Lord Mount Stephen, whose death at the age of 92, had just occurred. His great colleague, Lord Strathcona, died only a few years ago. It was the pluck and energy of a few men that carried through such an unexampled enterprise, unexampled whether from the engineering point of view, the contractors' point of view, or the great political effort made by the nation. The result should be noticed. The greatest Conference the world had ever known was sitting in Washington to-day, and while dealing with some things that concerned the Old World was primarily dealing with the vast problems of the Pacific. Everyone knew that the balance of the world was shifting from the Atlantic towards the Pacific. Any vast development of the future either of the British Empire or commerce generally or of the world at large, was going to take place mainly on the Pacific. It was the energy of the men referred to and the effort that Canada made at that time that gave the Dominion a great front on the Pacific. While minor processes were going on in New Zealand and Australia, Canada was now standing face to face with the great problems of the Pacific and had a large part to play in the enormously expanding range of human energy in that region, and with the vast populations of the East. The author also referred to the great granary of the West, perhaps the most important ever known, and had pointed out how the opening of the Panama Canal had changed the whole prospect of emptying that overflowing granary into the world's markets, and particularly into the United Kingdom. So vast was the country and so enormous its possibilities for grain production that not only was Canada going to make use of the sea route the author had spoken of, but had also undertaken to create another sea route, and she had almost completed a railway which gave the chance of two or three months' communication through the Hudson Bay, in order to have an outlet for the enormous resources of the North-West in grain production. He could remember distinctly when it was thought that the line of wheat production was well south, but it had been extended much further north in districts where it could not have been grown a few years ago. Moreover, he was told the other day that scientific research had now developed a wheat that ripened about a fortnight sooner. For years he worked with his old friend Sir Sandford Fleming, on the question of the great Pacific cable crossing to New Zealand and Australia. Sir Sandford then said that the time would come before many years when the Pacific would be crossed by many cables. As a matter of fact the United States had been compelled to make lines, and in the vast commerce which was sure to develop there would be cable communication on a large scale. It was British Columbia which was giving the British base, unless the place of the cable was taken by wireless communication. Facing the Pacific it was a most important thing that the tide of the British population of the best kind should settle on that coast. There was there one of the purest British populations established anywhere, while in the central prairies there was a mixed population from Galicia, Russia, and a hundred different points. It was providential that on the two sides of Canada East and West, there should be two of the most strictly British populations that could be found anywhere in the world. A thousand things were suggested to anyone who knew the country. He had been interested in seeing the big trees on the screen. He was in Vancouver a few years ago and met an old pupil managing a great mill. Some of his old boys were showing him the sights and gushing a great deal about British Columbia as everybody did, and it was said to him: "At our mill we used two tons of gun-powder last year to blow off the sides of the trees so that we could get them into the mill." He was entirely prepared to consider the story as a sort of joke, but next morning he drove with his friend down to the mill and saw the logs, with the sides blown off, being cut by two circular saws one above the other. There was no doubt at all that for the lecturer to come to the Society and show the developments going on in British Columbia, developments which materially affected the British Empire, was a very important thing.

Mr. Percy Hurd, M.P., wished to echo the cordial words of appreciation that had been spoken with regard to the paper. He was in British Columbia last year with his wife and they were astounded at the wonderful potentialities of that portion of the Dominion and also at the happily developed British characteristics there. At Duncans there was a large British community, and when the Imperial Press Delegates arrived at the handsome reception hall they found the luncheon tables set out in sections. There were separate tables for English, Scotch, Welsh, Australians, Indians, and so on. Being English himself and his wife Scotch they were separated, each having to take places amongst the race to which they belonged. That was an illustration of what Sir George had said, that there was in that section of the Dominion essentially a British development going on. And this development had its serious political aspect. There was no doubt whatever that in the development of the Empire, while it was necessary to bear in mind the implications of an Empire which had a

coloured population, it was necessary also never to forget that the foundations of progress of the Empire and the world lay in keeping as British as possible the elements of the population overseas. That raised many difficult questions which the author had most prudently kept out of his paper, but in looking at the emigration problem which was forcing itself to the front, owing to industrial conditions here and the adopted policy of the Government, it was necessary, especially on the part of those in the House of Commons who had to deal with votes and estimates, whether for emigration or fostering Empire export business, to remember that after all we were a great Empire family and to take care that our money and energy were applied so that the traditions which had made the British Empire great might keep it great in future years.

SIR GEORGE PARKIN said there was now constant connection between Vancouver and New Zealand and Australia. It gave an alternative route to those countries and he did not know anything more advantageous to the Empire than that Australians and New Zealanders in coming to England or returning home should have an opportunity of crossing Canada and seeing its advantages It would create that intimacy which was going to make the Empire more consolidated even than before

COLONEL SIR CHARLES YATE, Bt, C.S.I., C.M.G., M.P., in moving a vote of thanks to Mr. Wade for his paper, said he thought it would be readily acknowledged that the imagination of those present had been well stretched. It was beginning to be realised what Canada really was. As an old Indian he had taken particular interest in what had been said with regard to the communications from Vancouver not only to Australia and New Zealand, but to India as well. He was delighted to learn from the paper that the Canadian Government Merchant Marine was now running a regular steamship line from Vancouver to India, and he hoped it would progress year by year. The population question was a serious one. In Canada, as they had just been told, there was a mixed population in the interior, with a British population at each end. All he could wish was that that mixed population should be swamped by a British population at the earliest possible moment. It was to be hoped that under the present scheme of assisted emigration for ex-soldiers and others so many Englishmen would be poured into Canada that the mixed population would be reduced to a minimum as time went on.

MR. PERCIVAL A. HEITLAND (Furness Shipping Co., Ltd.) in seconding the motion, said there was one point in connection with the opening of the Panama Canal and the opportunities that arose for the development of Western Canada to which he should like to allude. Throwing the mind back to the time when the Panama Canal was not open, before the war, one could imagine if the war had never taken place there would have been in Canada a wonderful system of trans-continental railroads providing cheap land transport, and the opening of the Panama Canal would have furnished in addition the cheapest known means of transport, namely, by water. On the sea it was practically impossible for keen competition to be eliminated by any sorts of combinations or conferences for any great length of time; in the long run everyone had to come down to the lowest possible figure at which an ocean vessel could be operated. That was all to the good of communities which lived and worked in the vicinities of tidal waters. The figures given by Mr. Wade were sufficiently striking in themselves, but it was almost impossible to overestimate them, because railroad companies the world over had problems to deal with in getting down their cost of operation per ton mile, which were greater than any corresponding problem which the ocean operator had to deal with. All the railway development in Australia had been coastal with the idea of bringing the traffic from the developed coastal areas to the deep-water ports. It would be a big and somewhat doubtful undertaking to drive trans-continental railways through Australia and it was questionable whether they would be economical or helpful for a good many years to come, because of the wonderful advance in the race which other countries had already made in supplying Europe with raw materials and foodstuffs, particularly Canada

The motion was carried unanimously.

MR. WADE returned thanks, and the meeting closed.

WATER POWER RESOURCES OF THE UNITED KINGDOM.

The final report of the Water Power Resources Committee has been issued as a Blue Book, and consists of 178 pages, together with a series of elaborate maps illustrating the text. The Committee were appointed in 1918 by the then President of the Board of Trade, Sir Albert Stanley, M.P. (now Lord Ashfield. of Southwell) "to examine and report upon the Water Power Resources of the United Kingdom and the extent to which they can be made available for industrial purposes," and comprised, Sir John Snell (Chairman), Mr. G. S. Albright, C.B.E., Mr. H. F. Carlill (Board of Trade), Sir Dugald Clerk, K.B.E., F.R.S., Dr. J. F. Crowley, Major Sir Philip Dawson, M.P., Professor A. H. Gibson, Dr. H. R. Mill, Mr. A. Newlands,

C.B.E., Mr. G. C. Vyle (representing the Associated Chambers of Commerce and the Federation of British Industries), Mr. Ralph Walter (Ministry of Reconstruction), and Mr. D. J. Williams. In 1919 the Committee were instructed to consider further "what steps should be taken to ensure that the Water Resources of the country are properly conserved and fully and systematically utilised for all purposes," the following fresh members being added on the nomination of the Minister of Health: Sir Frederick J. Willis, K.B.E., C.B. (Chief Assistant Secretary of the Health Ministry), Mr. E. A. Sandford Fawcett, C.B. (Deputy Chief Engineering Inspector of the same department), Mr. A. B. E. Blackburn, M.Inst.C.E. (President of the Institution of Water Engineers), Mr. E. Sandeman, M.Inst.C.E., and Mr. W. A. Tait, M.Inst.C.E. Sir John Purser Griffith, M.A.I., M.Inst.C.E., was made an extra member, Mr. E. M. Konstam, C.B.E., K.C., succeeded the late Mr. A. J. Walter, K.C., and Lieut.-Col. D. Watts Morgan, M.P., took the place of Mr. Vernon Hartshorn, M.P., who resigned owing to pressure of Parliamentary and other duties. So far as Ireland is concerned the investigations were conducted by a Sub-Committee appointed directly by the President of the Board of Trade.

Realising that with the limited financial means at their disposal, it would be impossible to undertake a complete survey of the water power resources of the country, the committee concentrated upon obtaining particulars of as many schemes as possible for utilising particular sources which appeared likely to prove commercially practicable. Actual surveys were undertaken in a number of areas, and schemes from Government Departments and other sources were also examined.

Upwards of 50 witnesses were called. The reports and evidence obtained, which do not purport to be exhaustive in any way, establish a *prima facie* presumption that some 210,000 kilowatts (one kilowatt = $1\frac{1}{3}$ electrical horsepower) in the form of electrical energy could be developed continuously day and night throughout the year at an economic rate from those British schemes which were considered.

It is pointed out in regard to Great Britain that the potential electrical output of the commercially practicable schemes is equal to about 40 per cent. of the total output in the year 1917-1918 of the 410 British public electricity supply and electric tramway and railway undertakings operated by steam power; also, that the development of this amount of energy in steam stations would involve the consumption of nearly 3 million tons of coal per annum.

The Irish Sub-Committee consider that from a portion only of the water power resources of Ireland a continuous output of 11,300 kilowatts could be secured.

The bulk of the larger British water powers are situated in the Scottish Highlands, and although this district is some distance from the present great industrial centres, no part of it is far from the sea or the Caledonian Canal. It is suggested that the utilisation of the Scottish water powers might do much to arrest the depopulation of the Highlands.

The larger water powers of Wales are situated in the North Western part of the Principality The proposals of the North Wales Power and Traction Company, Limited, which involve the utilisation of several larger water powers in this district for public electricity supply purposes have already received the approval of the Electricity Commissioners.

In England, the main sources of water power are the small falls on rivers, and although the power available at any particular site is small, the aggregate output that might be produced by improving these sites, by installing modern turbines in the place of inefficient plant at existing sites, and the general improvement of the water courses is considerable. As a typical case, the Wiltshire Avon is cited. At present, plant is installed or about to be installed to generate in the aggregate 650 kilowatts, but investigation showed an *additional* output of 2,300 kilowatts could be procured. An examination of the Lake District did not reveal any large water power capable of commercial development.

The Committee consider that every inducement should be given to persons interested in power production to utilise for their requirements a perennial source of energy like water power, rather than a wasting asset like coal, and they recommend that the collection and publication of information regarding potential water powers should continue, and that financial assistance might be afforded by the State to water power undertakings during the difficult years of the constructional period.

A haphazard harnessing of the country's water power may, however, lead to partial developments which would prejudice the ultimate complete utilisation of the available resources and thus result in considerable waste. It is necessary, therefore, that some control over development should be exercised in the national interest. The Committee consider further that provision should be made for the ultimate acquisition by the State of all future water power undertakings, and they propose a system of terminable licences usually of long term for limiting the tenure of the undertakers of water power developments.

It is suggested that either the Board of Trade or the Electricity Commissioners, should be

specifically charged with the duty of studying, supervising and promoting the development of water power.

As regards Tidal Power, the Committee reiterate the recommendation made in their Third Interim Report, that this subject be specially studied by a Technical Commission with particular reference to the Severn Estuary, in regard to which a considerable amount of information has already been accumulated

A great number of different interests are concerned in the available supplies of water The predominant requirement is necessarily an adequate supply for domestic and sanitary purposes, but in any proposal involving the use or abstraction of water, the claims of steam and water power plants, trade and industrial consumers and canals and navigable water-ways need to be considered, and the prevention of pollution, the protection of fisheries, and the needs of agriculture from the standpoints of land drainage, irrigation and watering of stock have to be borne in mind. In Scotland the water resources are, comparatively speaking, abundant, and the population over considerable areas is sparse, and in consequence the conciliation of opposing interests can be effected by the Government Departments concerned, most of which are responsible to one Parliamentary head, the Secretary for Scotland. In England and Wales, however, the increase of population and the growing requirements of industry are responsible for a steadily increasing demand for water, and the problem of meeting future needs is giving rise to considerable anxiety. The Committee recommend, therefore, that a Water Commission having jurisdiction over England and Wales should be appointed mainly for the following purposes:—

(i) Subject, in case of opposition, to Parliamentary sanction, to allocate the water resources of England and Wales in the general interests of the community and to re-adjust existing allocations of water where hardship or anomalies are shown clearly to exist.

(ii) To adjust conflicting interests in connection with the use of water for a particular purpose.

(iii) To afford assistance to Parliamentary Committees before whom Bills relating to water may be heard, and to Government Departments concerned in the use and control of water for specific purposes, and also to the various local authorities and water supply undertakings.

It is also proposed that the existing local Boards and other bodies concerned with the separate water interests should be replaced by Boards, set up by the Water Commission, having general supervision over the water resources in a particular river basin or group of river basins. An Inter-Departmental Water Committee would serve to keep the Departments concerned with the various water interests in touch with one another and with the Water Commission.

The Committee consider that the Commission, in addition to promoting the actual conservation of the water resources of the country, would secure their more economical development by promoting joint action between water-supply authorities, by lessening the cost of the necessary inquiries into proposals for allocating water, and by centralising the collection of data relating to water resources It is proposed, therefore, that the expenses of the Water Commission should be defrayed in par by a levy on the water undertakings in England and Wales, and in part by the fees of applicants for powers to undertake works

Appended to the report are a "reservation" by Mr. Fawcett and a communication to the President of the Board of Trade, from Mr. Tait, both of whom disagree with the majority as to the formation of a Water Supplies Commission. *Inter alia*, Mr. Tait says: "Public opinion, already resentful at the number of permanent Departments or Offices, will be strongly opposed to the proposal as involving further expense to the taxpayers."

NOTES ON BOOKS.

THE VAN EYCKS AND THEIR FOLLOWERS By Sir Martin Conway, M P London: John Murray 1921 £2 2s

More than thirty-seven years ago Sir Martin Conway was st dyi g, writing and lecturing upon. Early Flemish artists He has also written many books on kindred and other subjects, such as explorations of mountainous regions in far northern Europe, in Italy, in north-west India (the Karakoram Himalayas), in Tierra del Fuego His distinction as an explorer and traveller, indeed, is even greater than that in other directions, where his authority is duly recognised. His peculiar qualifications for compiling a work on "The Van Eycks and their followers" is unquestionable Chapter I. opens with a sketch of the "Gothic Age," and conditions favourable to the development of art, especially that of painting in the Low Countries, France, and the Rhineland: but the stated purpose of the book—it contains over five hundred pages and about one hundred illustrations—is "to open the way for the ordinary "intelligent person to enter into this particular "domain of art and there orient himself and "find a solution of such difficulties as are to be "encountered on the threshhold." Like other historians of painters—Vasari, Horace Walpole, Crowe and Cavalcaselle—Sir M. Conway has (as they did in their day) made use of available materials and researches, paying special tribute to the work of recent date by the late Mr.

W. H. James Weale (whom he regards as the founder of the study of the van Eycks and their followers), and to that by Dr. Friedlander and Professor Hulin, "the two most eminent of the later generation of workers" He supplements his considerable adaptations of their dissertations with his own capital notes, observations, reminiscences, etc., of which he has an evidently considerable store.

The range of his exposition covers a period of nearly two hundred years, beginning with Hubert van Eyck (1366-1440) and ending with Peter Breughel (1510-1570)—who, Sir Martin considers, stands "as much alone in the mid-"sixteenth century as the van Eycks at the "beginning of the fifteenth; giants all three, "opening and closing the long procession of "lesser men who connected them" That eminent authority, Crowe, has written that "if the personal influence of the van Eycks "was smaller that of their work was immense, "and it is not too much to say that their "example taken in conjunction with that of "Van der Weyden determined the current and "practice throughout the whole of Europe "north of the Alps for nearly a century" Under such circumstances one does not detect distinctly that *air de famille*, which, in Sir Martin Conway's opinion, presumably should relate the work of a van Eyck with that some hundred and fifty years later of Bernard van Orley, for instance, "whose large pictures are unsympathetic to me" "his ability is obvious"—"We do not like you, Dr Fell is the attitude of most of us;" so writes Sir Martin somewhat sweepingly in his remarks upon the famous master, from whose designs (a single series of many others) the tapestries of the *Chasses de Maximilien* were worked, and hang splendidly on the walls of the *Galerie des Cerfs* at Chantilly. Even more sumptuous in effect of metallic glitter and rich colour like a missal painting of a Gothic style, are the David and Bathsheba tapestries in the Cluny Museum, the designs for which were adapted from paintings by such an artist as R. van der Weyden (Roger de la Pasture), who worked in the century before that of Bernard van Orley. Now it is well to bear in mind that a large proportion of the designs for earlier tapestries, such as those of the fourteenth and fifteenth centuries is due to enlarged versions of Missal illuminations or miniatures as they are sometimes called; and the first illustration in Sir M. Conway's book is a photogravure of an exquisite illumination by Hubert van Eyck. He was born "under "the shelter or protection of a Benedictine "Convent, in which art and letters had been "cultivated from the beginning of the eighth "century." Hugo van der Goes, a distinguished disciple of the van Eycks, was also a member of a conventual community. A cursory view of the historic continuity of painting necessarily embraces the activity of monastic establishments in rearing painters of illuminations, whose work is, as we point out, immediately related to cognate later work on the larger scale, exemplified in frescoes and tapestries. To such an important stage in the evolution of European painters as this, Sir Martin seems to us to refer lightly, as it were, *en passant* His main object is, apparently, to discuss minutely personal styles of certain notable painters (within a prescribed period) of panels and easel pictures

The numerous small scale black and white illustrations in the book cannot, of course, convey, colour effects, but they supply good indications of mannerisms of drawing and composition, light and shade, etc., by means of which typical features in the works of various masters, mostly "lesser men," may be compared. On these Sir Martin does not stint his opinions and criticisms; the fluency and volubility with which they are expounded furnish us with much engaging reading. Notwithstanding that the fascination, yielded by an abundance of stimulating assertions, deduction and pleasant anecdotage, may lead some mere investigators who are *in limine*, "on the threshold," to miss, in a a Shandean manner, the actual track of the "van Eycks and their followers," Sir Martin Conway may surely be cordially thanked for having brought the results of his prolonged and interesting labours before the public

IMPERIAL WIRELESS COMMUNICATION.

At the conclusion of the War, it was decided to complete the wireless stations at Leafield, in Oxfordshire, and at Cairo, and so make a real start with the proposed "Imperial Chain." At the same time, a Committee was appointed to consider the best ways of applying modern engineering knowledge to Imperial wireless telegraphy. This committee produced a scheme in due course, and in accordance with its recommendations, the planning of the various stations was subsequently referred to a small commission, of which Viscount Milner, then Secretary of State for the Colonies, was Chairman, and Dr. W. H. Eccles, F.R.S., Vice-Chairman. The construction of the stations was entrusted to the Engineering Department of the General Post Office, and corresponding departments overseas. The report of the Commission has been submitted to His Majesty's Government for consideration by the Cabinet, and will, it is expected, be published in the near future. Meanwhile, Dr. Eccles has performed a useful service in placing before the readers of *The Times* a broad statement covering the preparatory work that has been accomplished in connection with this undertaking.

Six principal stations are projected :—Great Britain, Australia, South Africa, India, Canada and New Zealand. Full consideration of the last two was postponed, owing to geographical conditions. An equilateral triangle some 5,000

miles along each side is formed by Australia. South Africa and India. The distances of Great Britain from South Africa, India and Australia, are respectively 6,000, 5,000 and 10,000 miles. To provide against interruptions from unfavourable weather, intermediate relay stations are designed, as well as instalments of thermionic valve plant for the purpose of generating electric waves, "which should be capable of adaptation at will to ranges varying from 2,000 to 11,000 miles, and capable of easy variation in strength from moderate to very intense, according to atmospheric conditions." Besides being strategically important it is anticipated that the intermediate stations will develop a local traffic.

The complete plan of the Committee contemplated an African branch, a separate Eastern branch, and, to assist British interests in the Far East, a station at Hong Kong, the last named to be worked as an off-shoot of Singapore.

In conclusion, Dr. Eccles adds that universal wireless progress during the 18 months which have elapsed since the Imperial Wireless Telegraphy Committee formulated their scheme has tended to confirm their conclusions that an Empire wireless service can be made continuous and trustworthy at reasonable cost by aid of the intermediate relay stations, and that only in this way can we escape the partial and erratic service which must accompany attempts at direct communication across the immense distances separating the chief centres of the Empire.

THE NICKEL RESOURCES OF CELEBES.

Much time has been spent in the exploration of nickel deposits in Celebes, according to the *Netherlands Indies Review*, and although it is not yet possible to illustrate the economic importance of such resources in figures, there is sufficient ground for considerable optimism.

The widely varying content on the one hand, and the absence of any system of measuring deposits on the other, renders it impossible to arrive with any certainty at an estimate of the available nickel ores in the island, and no attempt has yet been made to determine the minimum working content of each ore field or the costs of extraction. The usefulness of low-lying districts is entirely ruled by cost of transport.

Generally speaking, each nickel ore deposit consists of a few thousand tons in the form of nickel silicates, containing from 3 to 8 per cent. of nickel. Several deposits of this nature have been discovered, and in several places. a large number of veins close together make the fields of considerable importance.

In 1912, 800 concessions were granted in New Caledonia, and the production in 1911 and 1912 respectively was 152,000 tons and 108,000 tons, 120,000 tons and 72,000 tons of which were exported, and about 30,000 tons were worked up each year on the spot. The average content of the exported ore was 6 to 7 per cent. of nickel.

The falling off in production in 1912 was ascribed partly to the large stocks held in Europe, and partly to the high freights, which soon swamped the profits on an article which was valued by the Customs at 25 and 38 francs a ton. During the war, the production remained at about the same level, but owing to the shortage of tonnage the export of large quantities was impossible, and only 49,000 tons in 1915 and 31,000 tons in 1916 left the island.

As might be expected, efforts have been directed in New Caledonia towards the production of a substance containing more nickel. In 1912, two plants were smelting the nickel ores with sulphur ores in cupel furnaces to a matte containing from 40 to 50 per cent. of nickel, while a third, using hydro-electric power, employed an electro-metallurgical process. This last mentioned plant produces a ferro-nickel with about 50 per cent. of nickel. The commercial value of the matte, f.o.b. New Caledonia in 1912, was 700 francs a ton, and that of ferro-nickel considerably higher, not only because it contained more nickel, but also because its composition was such that it needed only one refining treatment to make it into a commercial product of general applicability, while the matte as a rule required at least two processes.

The water-power station in New Caledonia, with a capacity of 15,000 h.p., for the purpose of supplying a new smelting plant, not only to make ferro-nickel, but also to produce ferro-chrome direct from the ores, has proved its utility. The treatment direct of nickel silicates has not been undertaken in other countries with the help of electric furnaces.

Besides the preparation of ferro-nickel containing from 40 to 50 per cent. of nickel, a steel works in Central Celebes would be in a position to supply not only alloy steel containing about 1 per cent. of nickel and a smaller quantity of chromium, but also nickel containing from 1½ to 3 per cent. of nickel. Where the nickel ores contain a large percentage of magnesium they may be used for the production of a slag.

This shows how advantageous it is that the working of nickel should be carried on side by side with the steel industry. If the two operations are separated it will undoubtedly lead to increased expenses. The persons who supervise the metallurgical treatment of the iron ore can do the same in the case of nickel. A beginning can be made on a small scale and even should the venture not prove a success, which is extremely improbable, the staff, works—even the furnaces—can be put to other use.

GENERAL NOTES.

AUTOMATIC SUPPLY OF PETROL FOR MOTOR CARS.—A station for the automatic supply of petrol to motor cars is now being constructed on the Quay de Passy, Paris. The system has been in use in the United States for several years, and the Paris cisterns are a copy of those in use on the American roads. These roadside stations are simply tanks fitted with a feed pipe, and the quantity of petrol furnished to a car is automatically registered by a recording dial. In this way there is no trouble with petrol cans, or the necessity of driving to a garage, and the process of filling is much quicker than by the usual way.

ELECTRIC POWER ON THE RIVIERA.—It has been decided to utilize the water power in the mountains on the Riviera by the erection of a large power station. Sixty million francs will have to be provided for utilizing two water falls, one at Boucairon and the other at Saint Etienne de Jinée and erecting the necessary machinery. It is quite probable, if this is done, that this district will, in the near future, become an industrial centre, as at Grenoble and other localities in the French Alps, where large manufactories have been developed through the use of water power. It is intended that this new station will supply electric current to Nice and other towns on the Riviera.

THE FRENCH EXPORT TRADE.—The improvement in French trade is shown by the continual increase in the exports, which during the first four months in 1921 in spite of the universal economic crisis, reached a total of 7.400 millions of francs, as compared with 6.288 millions during the same period in 1920. On the other hand, the imports during the same period decreased to 7.118 millions francs, thus showing an increase in value of exports over imports of 282. millions francs, instead of the formidable deficit of the first four months of 1920. These fresh indications of France's economic recovery should stimulate production and economy in that country.

CULTIVATION OF CHINESE TEA PLANT IN PARAGUAY.—In the Department of Villarica, Paraguay, there is a nursery for the cultivation of the Chinese tea plant and its adaptation in that country, according to "Commerce Reports," seems very propitious. Experiments to acclimatize Chinese tea have been made in Paraguay on former occasions with favourable results. There are two varieties of tea—Bohea and Viridis. The experiments with the former have shown that it is difficult to grow it in Paraguay; the latter, however, is readily acclimatized.

BOARD OF ARCHITECTURAL EDUCATION.—The Royal Institute of British Architects have published a short pamphlet containing advice to candidates for the Institute's Examinations, together with a list of books recommended to those who are studying architecture. This pamphlet may be obtained free on application to the R I B A., 9, Conduit Street, W 1.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, JANUARY 9..Geographical Society, 135, New Bond Street, W., 8.30 p m. Sir Philip Brocklehurst, "Across Wadai"

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Miss C. L Maynard, "The Bible of the Twentieth Century."

Surveyors' Institution, 12, Gt. George Street, S.W., 8 p.m

TUESDAY, JANUARY 10..Petroleum Technologists, Institution of, at THE ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m

Civil Engineers, Institution of, Gt. George Street, S.W., 6 p.m

Colonial Insittute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Lord Morris, "The Birth of the Overseas Empire and its Development."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr A. Wilcock, "The Decorations of Versailles."

Anthropological Institute, 50, Gt. Russell Street, W C., 8.15 p m. Mr. J. Whatmough, "Rehtia, the Venetic Goddess of Healing."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Dr. A. McCance, "Internal Stresses in Metals."

Royal Institution, Albemarle Street, W., 3 p.m. (Juvenile Lecture.) Prof J. A. Fleming, "Wireless Telephony." (Lecture VI.)

WEDNESDAY, JANUARY 11. Rubber Industry, Institution of, at THE ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6.45 p.m

Industrial League and Council, Caxton Hall, Westminster, S W., 7.30 p.m. Mr. R. Stelling, "A Fair Day's Work for a Fair Day's Pay."

THURSDAY, JANUARY 12..Aeronautical Society, at THE ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C. 3 p.m., (Juvenile Lecture) Major D. C M. Hume, "Boats that Fly"

Antiquaries, Society of, Burlington House, Piccadilly, W., 8 30 p.m

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. 1. Dr. C. J. Peddle, "The Manufacture of Optical Glass." 2. Dr. J. W French, "The Barr and Stroud 100-ft. self-contained Base Rangefinder." 3. Mr. T. Smith, "The Optical Three Apertures Problem."

Historical Society, 22, Russell Square, W.C., 5 p.m. Mr. F. W. Buckler, "The Political Theory of the Indian Mutiny."

Mechanical Engineers, Institution of (Midland Section), The University, Birmingham, 7.30 p.m. "Dr. Leonard Hill's Katathermometer."

Metals, Institute of, at the Sir John Cass Technical Institute, Jewry Street, E.C., 8 p.m. Col. N. Belaiew, "The Inner Structure of the Crystalline Grain."

Central Asian Society, at the United Service Institution, Whitehall, S.W., 5.30 p.m.

FRIDAY, JANUARY 13..London Society, at THE ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Lady Cooper, "The Banks of the Thames."

Japan Society, 20, Hanover Square, W., 5 p.m. Mr. A. B. Maiden, "Japan, the Flower of the East."

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 145.

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FRIDAY, JANUARY 13, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FUND FOR PURCHASING THE SOCIETY'S HOUSE.

*SECOND LIST.

	£	s.
Amount previously acknowledged	40,201	13
Khoo Sian Ewe, Esq., J.P.	100	0
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	£40,678	3

The above list includes all subscriptions received up to January 9th. Further lists will be published in the *Journal* from time to time.

*The first list was published in the *Journal* of December 2nd, 1921.

NOTICE.

NEXT WEEK.

WEDNESDAY, JANUARY 18th, at 8 p.m. (Ordinary meeting). JULIAN S. HUXLEY, M.A., Fellow of New College, Oxford, "Recent Advances in the Determination of Sex in Animals." PETER CHALMERS MITCHELL, C.B.E., M.A., D.Sc., LL.D.,

F.R.S., Secretary of the Zoological Society of London, in the chair.

Further particulars of the Society's meetings will be found at the end of this number.

MANN JUVENILE LECTURES.

The first of the series of Juvenile Lectures under the Dr. Mann Trust, was delivered on Wednesday, January 4th, by Mr. William Reginald Ormandy, D.Sc., F.I.C., F.C.S., the subject being "Clay—What it is—Where it comes from—and What can be done with it." The Chair was taken by Sir Herbert Jackson, K.B.E., F.R.S.

Dr. Ormandy told the audience he did not propose to give a lecture, but preferred to call it a chat. He supposed they all knew what clay was, although it was very difficult to define it, because it consisted of so many things. Its one characteristic however, was plasticity, as the moment the right quantity of water was mixed with it, it could be moulded with the hands and would retain the shape given to it. He said we could not make a material plastic and that the plasticity of clay was something inherent—a property given to it by nature. Mankind, long ago, discovered the possibilities of utilising clay, for in the Book of Job it was stated that there were men who lived in houses made of clay, i.e., bricks made from clay, merely dried in the hot tropical sun. The Tower of Babel was also built of bricks that were burnt in the fire. There were references in the Book of Job, to potsherds (i.e. broken pieces of pottery) being used to scrape oneself with. The Egyptians and Assyrians and many other races used unburnt blocks of clay in making out their bills and accounts, etc. When they were brought over here, it was necessary, owing to our moist climate, to burn the tablets in order to preserve them. But they still retained their shape and from the inscriptions on them we were able to tell how the people of that age lived and what they did.

Kaolin, the scientific name for the purest sort of clay, was a Chinese word, and this kind of clay was brought over to England about the middle of the 17th century. From this clay the Chinese had for over 2,000 years made a porcelain equal in quality to anything we had been able to manufacture with all our scientific knowledge. It was rather extraordinary that at the very time when all the world was hunting for materials similar to those from which the Chinese made their porcelain, we had in England some of the finest deposits of suitable clay. In Dresden, in 1710, a man riding on horseback noticed that his horse's feet were covered with a white material. Men of fashion in those days used starch for powdering their hair and he thought this material could be used instead of starch. The German chemists, however, found that the powder was kaolin, and this led to the establishment of the celebrated Dresden China Works. In France, in 1765, a lady discovered a deposit of very white clay, and as soap was expensive in those days, she suggestrd to her husband that it would be useful owing to its soapy nature for cleaning purposes. French chemists, however, found out its true nature, and the lady's discovery led to the foundation of the world-renowned Sèvres China factory.

Clay was also brought to this country from Virginia and a man named Cookworthy recognised that there was similar material in Cornwall, and started in 1773 the well-known pottery at Plymouth, which was afterwards removed to Bristol. There were many distinct varieties of clay the red and yellow clays used in brickmaking; the strong clays of Poole and Devonshire, which were quite soft and plastic and could be moulded into any shape; fireclays, which withstood very high temperatures; and shales found under coal seams from which sanitary ware was made. Some shale was so hard that it required to be out in the open for 2 years in order to become plastic. A slate quarry was nothing but a great pit of clay deposited perhaps millions of years ago, subjected to very great pressure and heat, and no longer capable of taking up water. Fuller's earth was a special sort of clay. The oil shales were also more or less clay in which oil, which had been formed by nature, had been sucked up by the shales and retained there until they were dug out, put into retorts and the oil distilled from them.

Clay played an important part in one of our great industries—the manufacture of pottery—and although we only started at a very late period, as compared with China and Japan, it was now a great industry and the high grade china and stoneware made in this country were unequalled, both for quality and artistic design. It was from the ridges of granite to be

found in Cornwall, that the china clay came and he described some of the uses of clay in paper making and the textile industries. An interesting series of lantern slides (some of which were taken with polarised light) was thrown upon the screen, including sections of quartz and feldspar, views of quarries and mines in Cornwall, and the different processes for treating the clay until it becomes the pure china clay of commerce. There was also a view of a sample of extra pure clay, lent by Mr. D. N. Laurie, with a perfect ammonite fossil form in china clay; and a diagram giving details of two bore holes at Bovey Tracey, in which there were 17 distinctly different beds of lignite and 556 feet of clay. When they remembered how long it took for an inch of clay to be deposited in a lake, they would realise the immense period of time required to form such a deposit of clay. Dr. Ormandy briefly indicated the scope of his second lecture and the meeting then adjourned.

Specimens of granite, quartz, felspar and mica were kindly lent to illustrate the lecture by the Director of the Geological Museum, Jermyn Street, S.W., and the Society and the lecturer are also indebted to the English China Clay, Ltd., of St. Austell, for the samples of china clay, china stone and other products, as well as for many photographs from which slides were made. Thanks are due to Mr. Northall Laurie for the loan of his fine coloured micro photographs.

PROCEEDINGS OF THE SOCIETY.

SIXTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 7th, 1921.

H.E. THE BELGIAN AMBASSADOR in the Chair.

THE CHAIRMAN, in introducing M. Emile Cammaerts, the author of the paper, said it was a very great pleasure to him to find himself again at the Royal Society of Arts, which had many connections with Belgium. Several Fellows of the Society had given the people of Belgium proofs of their warm sympathy. There were many homes in Belgium whose inhabitants remembered with heartfelt gratitude the name of Sir Henry Trueman Wood—who was the Secretary of the Society at the beginning of the war, and was now a Vice-President and member of the Council—because, with the help of his daughter, Sir Henry succeeded in starting and maintaining at Aldeburgh a school for young Belgian girls who had sought refuge in this country during the sad times of the war

The paper that was to be read that evening was not the first dealing with Belgium to be read before the Royal Society of Arts During the war, Sir William Goode, the Secretary of the National Committee for Relief in Belgium, gave the Society a remarkable account of the activities of that Committee, which, as those present would remember, collected funds for the American Commission for Relief in Belgium Also, he had personally attended a meeting of the Society when a paper on Ypres was read by the Belgian Director of Fine Arts, M. Lambotte, at which meeting the Archbishop of Canterbury spoke. Since the war, Sir Cecil Hertslet, always a true friend to Belgium, had been able to give a vivid account of the work of reconstruction carried out in Belgium since the Armistice.

M. Cammaerts, who was going to speak on "Literature and International Relations," was well known to everyone present He was one of the greatest Belgian poets He had charmed many by the grace of his Muse, and during the war his patriotic strains often upheld the courage of his compatriots Although M Cammaerts' tastes and great talent drew him towards literature, he was also particularly competent to speak on all matters concerning the intercourse of nations, and most especially on the relations existing between Belgium and Great Britain Thirteen years spent in a country which had become a second fatherland to him had given him experience of life in England as well as in Belgium Being a literary man he was well qualified to speak on the subject he had chosen for his paper - which was not always the case with those who spoke about literature The work which M Cammaerts had accomplished had afforded him an opportunity to appreciate the immense advantages which could be derived from the development of literary intercourse between nations, and at the same time he had seen the difficulties which must be overcome in order to bring that about He would state in his paper what, in his opinion, were the best means of doing away with the intellectual barriers between different countries. Literature would in that way serve the highest interests and the purest aspirations of international politics.

The following was the paper :—

LITERATURE AND INTERNATIONAL RELATIONS.

By EMILE CAMMAERTS,

Of the Anglo-Belgian Union.

Without attempting to prophesy, we may say that the present period will be considered, in the future, as a great period of political and intellectual transformation

comparable to that which Western Europe experienced in the 16th century. The Renaissance coincided with the creation of the centralised modern state, resting mainly on the increased power and prestige of the King, which superseded the communal and feudal units into which each country had been divided in the Middle Ages. The present transformation is somewhat different since the creation of a kind of super-state, ruling and policing all the nations of the world, seems to have been definitely discarded. The Washington Conference and the League of Nations may, nevertheless, be considered as tentative means to bring about a state of world citizenship. Such a transformation can only take place in democratic nations if the majority of the people take some interest in it, that is to say, if every citizen, besides his local and national interests, is able to exert personal influence on the course of international events. We are urged to influence, through public opinion, our respective governments, and the delegates whom we send to the Assembly of the League of Nations and to other international conferences.

This is surely a new departure. Up to 1914, the general public had only taken a secondary interest in foreign affairs, leaving the respective foreign offices and the diplomats to struggle with the difficulties as best they could. It was even assumed that foreign politics, dealing with questions in which all citizens were equally interested, stood outside ordinary political rivalry. We can only congratulate ourselves on the new outlook, but we must be prepared to face certain serious difficulties. If the old method of so-called "secret diplomacy" did not succeed in preventing international conflicts, we must not assume that the new method of open discussion will necessarily be more successful, unless some very energetic measures are taken to educate public opinion internationally, as it has been educated nationally. Certain symptoms of danger are already apparent. They may be seen, for instance, in the hasty criticism of certain decisions of the League of Nations by some of the most enthusiastic supporters of the movement. They may be seen also in the influence exerted by internal politics on some people's views of foreign affairs. Why and how one's personal opinion on home policy should affect one's view on the Silesian question, for instance, remains a mystery, but we must, nevertheless, recognise the fact that the partisans or opponents of the government in every country are inclined, at present, to uphold or to condemn the government's foreign policy, not on its own merits but simply as a party question. If this tendency were to develop it is easy to imagine that, instead of removing the causes of friction, it would do a great deal to multiply them, and we should soon have to regret the time when foreign and internal politics worked on more or less distinct lines. It is, therefore, greatly to be hoped that some steps will be taken in every country to enlighten public opinion sufficiently to allow every citizen to consider foreign questions without prejudice. A certain amount of criticism is unavoidable, and, to a certain extent, justifiable, but it is urgent that the critic should be well-informed and should be able to realise the position occupied by the citizens of other nations with a certain amount of sympathy.

Are we, at the present time, properly equipped to prepare children and adults for their duties as world citizens? Or must we re-adjust our present means of education to the new international situation created by the war?

It will be generally admitted that the various channels through which such an education must be given are the school, the formation of certain societies, the press, and literature in general. Let us examine briefly how matters stand in these various departments of intellectual activity, and what may be done to increase their efficiency for the improvement of international relations.

It is rather the fashion to criticise education. Educationalists are faced with the very difficult problem of dealing with a wider and wider field of knowledge in the same limited amount of time. Even supposing classical studies to be entirely sacrificed, which in many ways would be greatly to be deplored, it has become scarcely possible to provide a complete modern education within the limits of school years. It is, therefore, urgent to utter a plea in favour of three branches which are essential to international education; History, Geography and Foreign Languages. It is unnecessary to insist on the value to any student of foreign affairs of a general and sound knowledge of History and Geography. We cannot open a paper without realising

how much we are handicapped by the lack of it. We cannot discuss foreign matters without realising how many educated men and women remain ignorant of facts which, in any civilised society, ought to be common knowledge. I have been asked again and again, for instance, how the Belgians could show such patriotism, considering that their nation only came into existence in 1830, and, only a few days ago, I was told by a certain clergyman that the judgment of the League of Nations was unfair because it placed a great number of Germans under Polish rule in Silesia, while no Poles were placed under German rule. The same kind of observation might be made by any Britisher travelling abroad, should any question relating to British history, like Ireland, for instance, come under discussion. Whatever curtailments are contemplated by our educationalists, the position of History and Geography in the curriculum must be maintained, and even strengthened. We might, also, perhaps, devote less time to our own country, whose principal features are bound to be impressed upon us by experience, and more to foreign countries, with which we are not naturally brought into contact.

Some people hope to solve the language difficulties by generalising the study of some universal language, such as Esperanto. Within certain limits, and for practical use, such a language may render considerable service, but, from the educational point of view, it has little value. A language is more than a vehicle of expression; it has been slowly built and transformed through centuries of evolution, and is stamped with the spirit of the people who created it. A study of French, for instance, not only allows us to talk more or less freely with the French people, and to read French books, but it teaches us, more than anything else, the genius of the French people. Every idiom is a psychological discovery and nothing brings us closer to a people's thoughts than a thorough knowledge, not only of what they say, but of the way they say it. If one might give advice in this matter, one might suggest that if less concentration is needed in history and geography, more concentration would be useful in the study of foreign languages. It is far better to know one language thoroughly than to have a smattering of three.

It is to be hoped that, in the future, every adult will deem it his duty to join some society aiming at bringing nations closer together. The League of Nations Union, with its hundred thousand members and its three hundred branches in Great Britain has started this kind of work with an enthusiasm which cannot be too much admired. Whatever the future of the League, and whatever form it may take hereafter, we trust that this great organisation will continue to develop and to further interest, not only in the League or any similar association, but in all international matters with which such an association may have to deal. It is, however, beyond the scope of the League of Nations Union to link together all the nations of the world. No single association can cope with such a tremendous task, which can only be dealt with through specialisation. A good many dual associations existed before the war, a good many more have come into existence lately. We have already in London an Anglo-French, a British-Italian, an Anglo-Swedish, an Anglo-Norwegian and Anglo-Batavian, and last, but not least, an Anglo-Belgian Union. Each of these Unions ought to bring together all those who for intellectual or economic reasons are specially interested in the two countries. Their activities ought not to be limited to the relationship between a small colony and the bulk of any particular nation; they ought to be pursued on parallel lines and simultaneously in both countries, so that all those engaged in increasing the interest in one country, in the one centre, should realise that a similar work is being undertaken, on the other side, and that for every friend they enlist for, let us say, Belgium, their fellow members are enlisting a friend for England. Our Anglo-Belgian Union has drawn great strength from this friendly rivalry, and when the idea of dual Unions is fully developed, we may imagine a net-work of such associations all over the world acting for each League of Nations Union as a kind of "agent de liason." Such a net work, woven quite independently of any particular class or party, would be very difficult to rend. It would be the business of each Union to prevent the creation of any ill-feeling, and to check its growth, correcting mis-statements and clearing away mis-understandings as soon as they appear.

When all this educational work is accomplished, the greatest influence for evil or for good will still remain with the journalist and the writer. It is scarcely necessary to remind ourselves of the work accomplished on both sides by the press during the war. While the armies were struggling on the battlefields, an intellectual battle was waged behind the lines, attacks followed by counter attacks, accusations being disproved or confirmed. There was scarcely any writer, any professor, in the countries engaged in the war, who did not take a certain share in this work. Here, also, we were unprepared and obliged to follow the example of our enemy, and to adopt the name they were pleased to give to this activity—propaganda. It was rather an unfortunate name, because it caused, in certain quarters, the impression that news was adulterated according to the needs of each party, and that when history came to be written all this literature would become practically valueless. Some efforts have been made in this country, lately, to bring before the public certain documents issued by German propaganda in the hope that, the other side having been able to express its views, responsiblities would be more or less evenly balanced. I do not think that these efforts have been particularly successful, and that such publications, for instance, as that of the translation of the German White Book (dealing with the acts of the German Army in Belgium), are likely to alter the verdict of history. It must not be forgotten that if it was in the interest of the German propagandist to bolster up a bad case by eloquent denials and unfounded counter accusations, it was equally to the interest of Allied propaganda, since the word must be used, not to spoil a good case by anything more than the truth.

All the experience we have acquired in press matters during the war must now be devoted to the maintenance and strengthening of peace. Even among the Allied nations, differences of interest and of outlook have made their influence felt since the Armistice. Now that many questions which never reached the public are openly discussed, the press has to assume new responsibilities. I hasten to say that, in this country, almost every important journal has, up to the present, resisted the temptation to cater for sensationalism, and has given an example to the world. If there are any improvements to be suggested it would be in the direction of better information from abroad. Foreign news reaches us, either through agencies or through correspondents. It is satisfactory to notice that certain agencies which were rather inclined to try to increase the number of their subscribers by sending unconfirmed and sometimes mischievous news, have been strongly discouraged from indulging in this practice by the discrimination of editors. On the other hand, the way in which views from the foreign press are sent to us is not yet satisfactory. Far too much is made of the opinions of extremist papers, with a small circulation, which do not represent any important fraction of public opinion, while moderate statements, from more influential quarters, are totally ignored. There is still a tendency to spread, in each country, views from abroad which are most opposed to the general trend of opinion. It may add some flavour to the reading of our evening papers, but it is neither accurate nor conducive to good understanding.

It is often discussed among journalists whether it is better for a paper to have foreign correspondents belonging to the country in which the paper appears, or to the country from which the news is sent. Whichever method is adopted, it is essential that the correspondent should have a thorough knowledge of both countries in order, on one side, to provide correct information, and, on the other, to present such information with due regard to the temperament and inclinations of the people for whom he writes. What happens frequently now-a-days is that the journalist, to whom this mission has been entrusted, vents his own special views and grievances in a foreign paper which cannot possibly share his interests, or, that, if he belongs to the country for which he writes, he is inclined to strengthen the national prejudices of his readers instead of dispelling them. While an agency is mostly concerned with the accuracy of the news and the rapidity of its transmission, the correspondent's task ought to be to explain the internal difficulties which confront the country in which he resides, and the way these difficulties affect its foreign policy. To take a concrete example: both the British and the French might have obtained a fairer opinion of each other's policy if all foreign correspondents, writing for both countries, had kept in mind, on one side, the difficulties facing the Empire, and the

urgent necessity for restoring normal conditions, and, on the other, the sincere and not altogether groundless, apprehensions caused by a possible recurrence of German militarism. This task requires a good deal of tact and intellectual humility. It is difficult for any man to place himself in the situation of another. It is still more difficult for a nation to sympathise with another nation's troubles. The spirit of the crowd is inclined to wax passionate and intolerant, but if the world of to-morrow is to be built, it is not going to be built on intolerance. It might, perhaps, be a very good thing if foreign correspondents belonged neither to the country for which they write, nor to the country from which they write. Referring to the example given above, I should suggest that a well-informed Belgian correspondent might perhaps serve the interests of both countries better than anyone else, for, as a Belgian, he would readily recognise British economic difficulties and French anxieties with regard to the Rhine frontier.

Even supposing our education and our press organisation better adapted to the international necessities of the future, a considerable obstacle has still to be overcome before friendly relations can really be established between the nations of the world. The most accurate information, the most moderate and sympathetic comments will not suffice to remove friction deriving from differences of temperament. We reach here the very bed-rock of our difficulties. Just as there are individual temperaments which must be realised and understood before any solid friendship can be founded, there are national temperaments which must be realised and understood before a real peace can be established, not merely a physical peace excluding the use of force, but a spiritual peace checking envy and intrigue. Behind almost every diplomatic difficulty we may discover a temperamental difficulty. Conflicts of interests are only one aspect of the question; the psychological element is far more important. We not only use different languages, but the same words convey different meanings, whether they are used in one country or another. Internationalists usually find it convenient to ignore this fundamental difficulty; they boldly declare that national temperaments determined by climate, surroundings, centuries of religious and intellectual life, do not exist, but those who have at heart the reconciliation of mankind must not be blind to facts and shirk the greatest obstacle in their way. The tremendous influence of tradition faces us at every turn. It may be unfair, it may be misguided, but it is there, nevertheless. The example of Ireland stares us in the face at the present moment. As an extreme instance, it may be interesting to remember that in some parts of Belgium "Spaniard" is still preserved as a term of abuse.

International education will, therefore, not be complete unless a certain knowledge of foreign art and foreign literature helps us to realise our differences. Nowhere is the national temperament better expressed, nowhere can its expression be better studied and admired. It is a fact of common knowledge, that the greatest artists and the greatest writers whose genius is recognised all over the world, have been devoutly attached to their particular town, or country. There is no such thing as international art or literature, and there very likely never will be. The greatest painters, the greatest poets, can only represent what they see, or what a long tradition of ancestral knowledge leads them to think and to feel. It thus happens that the classics of modern languages, such as Dante, Shakespeare and Moliere, which are studied all over the world, give us the key of Italian, British and French temperament. Quite apart from scholarly interests, the knowledge of the masterpieces of foreign literature leads us towards a higher understanding of our respective national character, and we may hope that the time will come when, instead of regretting these differences, we shall rejoice over them as so many signs of the richness and variety of human nature.

There is, in this direction, a serious obstacle to overcome—the scarcity and insufficiency of translations. It seems strange that, in our enlightened century, British people should still have to complain of having no adequate rendering of Molière's works, while, with the exception of one or two dramas, the translation of Shakespeare into French can hardly be called satisfactory. When we turn to more modern work, the intellectual gap created by the difference of language is still more noticeable. The French only began to know Ruskin shortly after his death. I did some pioneer work in this direction fifteen years ago, and was rather aghast to learn, when coming to England, that the great art prophet, who

had scarcely begun to be popular in French speaking countries, was already almost forgotten in the country of his birth.

Some people will tell you that the deficiency in translation is due to the fact that, in many cases, an adequate rendering of the original is almost impossible. We may thus attribute to extra-refinement what is merely the result of lack of organisation and neglect. If translations are inadequate, it is not because they present insuperable difficulties, but rather because all the best men who might write them with great success are engaged on more profitable work. Towards the end of the Middle Ages and the beginning of the Renaissance, almost every work of interest passed from one country to another, and the greatest writers did not think it below their dignity to devote years of labour to the creation of a new version. This intercourse was so constant, that scholars still discuss whether a romance, poem or play originated in one or the other of the Western European countries. Let me quote, among scores of others, the example of your morality play, "Everyman," and its Flemish version, "Elckerlyk." If this work was done in centuries when it took weeks to go from one capital of Europe to the other, can it not be carried on in the age of aeroplanes and wireless telephony? We are told that the rapidity of communication is bound to bring us more closely together, but unless this material and economic intercourse is strengthened by moral and intellectual intercourse, it is scarcely conducive to better relations.

We have reached a marvellous development from the technical point of view, but this development is not balanced by adequate intellectual intercourse, as those know only too well who endeavour to keep up with foreign literature when residing in another country. It thus happens that the most foolish prejudices which estrange one nation from another have not yet been eradicated, and they are just the prejudices which cause most harm, because they misinterpret essential characteristics of race or nation. I should think that the majority of Britishers are still persuaded that French demonstrativeness is a symptom of sentimentalism, while the majority of the French still adhere to the familiar legend according to which Britishers are typically cool and phlegmatic. Now, for anybody in the least acquainted with both literatures, it is obviously the reverse which is true. If the French display such profuse politeness, is it not because they are stern realists? If they yielded to the temptation of expressing their views in straightforward speech, it might perhaps wreck the amenities of social life. If the British, on the other hand, seek refuge in a cold exterior, is it not, to a great extent, in order to defend themselves against their over-powering tendency to sentiment?

Since we possess different temperaments, it is high time that we should learn to interpret them correctly, and to take them into account in all manifestations of social international life. Contemporary literature is often confused and misleading. It is difficult to discern, among the celebrities of the day, those who are most likely to outlive their period, and who are specially representative of the nation. But the great classics of the last centuries remain, for the true internationalist, a tower of strength. The student will find in them the explanation and even the justification of a great many things which would otherwise hurt his feelings and undermine his hope in the future of mankind.

When all is said, the two pitfalls of international relations may be attributed, on one side, to an exaggeration of national feeling, and on the other, to a total absence of it. These two attitudes of mind are all the more dangerous as they are bound to attract both the ignorant and the impassioned. We have seen the German people so intoxicated with their own glory as to try to impose, through every means at their disposal, their rule and their culture on the world. We have seen the Russians, or, at any rate, a great number of them, so carried away by idealist nihilism as to wreck their own country and do their very best to wreck others. Instead of being an obstacle to peace, enlightened nationalism is the very condition of the establishment of friendly relations between nations. It is only through the devotion which you have for your own country that you may understand and respect the devotion other people may have for their country. It is only through the knowledge of your own limitations and weaknesses that you can acquire sufficient indulgence to recognise and to excuse similar weaknesses elsewhere. Patriotism and internationalism, properly understood, are not opposed, and the artists and the writers who have been able, through their genius, to make their national

temperament better known and better appreciated all over the world, are, perhaps, the first pioneers of a true League of Nations.

DISCUSSION.

THE CHAIRMAN (H.E The Belgian Ambassador) said he was sure everyone present had listened to M. Cammaerts' interesting paper with the same pleasure that he had experienced himself The author had shown that literature was, perhaps, the best means of developing and improving the relations and good feeling between the nations

DR GEORGE MACLEAN (Director, British Division of the American University Union in Europe) said he was sure all those present had been drawn to the meeting by the name of M Cammaerts and also by the most timely subject chosen for the paper--literature and international relations He was a little surprised that the author elevated journalism into the field of literature, and he was the more surprised at that because he had just been reading one of the most admirable reports ever issued by a Government Committee--the Report of the Committee on the Teaching of English, of which Committee Sir Henry Newbolt was Chairman -- and in that report, while due respect was paid to literature and to how English should be taught and while the report covered the whole field of education in English, even the drama, there was no reference whatever made to journalism. He hoped that the ideal view of journalism which the author had might one day be attained. The genial humour of the author appeared in the paper time and again, and he suspected that the author had been using what was known in the United States as "molasses" in place of vinegar in order to win the journalists to higher things He had expected that the whole paper would be devoted to what the author called "general literature" literature in the highest application of the term--but he recognised the wisdom the author had shown in dealing with what the schools might accomplish and also the international agencies Among those international agencies there was certainly none more successful than the American Commission for Relief in Belgium, the funds of which Mr. Hoover was chiefly instrumental in raising, the surplus, some 60,000,000 francs, being used by Mr. Hoover to endow permanently the Belgian Relief Fund to promote the exchange of professors and students between Belgium and America. That was in line with the practical thought that the author presented when he indicated that there was such a thing as a good side to propaganda, in spite of the prejudice against it. He thought everyone would agree that what was required was some persistent, normal relationship that could not be labelled in any sense propaganda, and that was attained in the Commission for Relief in Belgium Fund. There were no less than seven of such foundations at present at work in the United States such as the American Scandinavian Foundation. It was very significant and full of promise for the coming international era that there were in existence those foundations and such bodies as the University Bureau of the British Empire and the American University Union in Europe, all at work to promote understanding and the common intellectual life among the nations. Still more promising was it that the students themselves, in great organisations in the Universities of the different nations upon the Continent and of the British Empire and of the United States, were forming international circles for the study of international relations. He had been informed that there were now 90 societies in 90 different Universities and Colleges in the United States under the name of International Clubs, devoting their time to the study of geography and of international questions and even literature, and holding meetings for that purpose After all, it was literature in the supreme sense of the term as De Quincey taught it--the literature of power and not the literature of knowledge--that united nations An illustration of that was provided by the way in which the Greeks conquered Rome, and when the Renaissance came it was Greek letters that gave it birth and rejuvenated the nations of the West. Again, taking even a rationalistic view of the Bible, what was it but the great literature of the Hebrews which had conquered the nations of the Occident ? He thought literature might be defined as the embodiment in letters of the life of the soul The author had shown the value of the soul life of each of the nations, but literature in the highest sense represented the soul of humanity, and, therefore, comparative literature was needed, not only for the sake of international relations, but that people might know the value of their individual and of their national souls and attain to a vision of the possibilities of their race Therefore, literature would be of inestimable value in promoting the new international era. Abraham Lincoln, the backwoodsman, uttered one piece of literature that would be immortal among free peoples in his Gettysburg speech, and that piece of American literature was to-day going round the world and uniting the nations to continue the fight of freedom for peace as they fought together for victory in the war. During the summer of the present year he had been in Scandinavian countries and frequently asked the people there if they knew of any American authors whose works they read in translation or otherwise, and two or three names were frequently mentioned, such as Longfellow and Emerson. If Americans had contributed three or four to the immortals whose works were translated and read in different nations, he had hope for the future of his people. One of the secrets of the assimilation of the many elements that made up the American people was to be found in the

use of literature. There were Chairs of Comparative Literature in many Colleges in the United States and in every College there was a Professor of English Literature, which was always taught because of the glory of English Literature that was the heritage of all. A National Anthem should be literature. He thought the National Anthem of America, "My country, 'tis of thee" was literature—it was simple, but it had soul in it and appeal in it to every man who was an American. At a great American gathering there would be assembled people of all extractions, but people who had come to America because they loved it, and they would rise and sing that National Anthem, and it was also sung by the children in the schools—whether they were Russians, Jews, Bohemians, Italians, or of any other nationality.

MR. LAURENCE BINYON said he was in cordial agreement with every word of the paper. He was delighted with the singularly broad tone and the wise temper of all that the author had said, and was particularly pleased with what he had said about nationalism and internationalism. Many people held the view that the one cure for the present unfortunate state of the world from which we were trying to emerge was to destroy the sentiment of nationality, but personally he agreed most profoundly with the author's view on the subject The sentiment of nationality could no more be destroyed than love or religion. Forces such as those had had devastating effects on human life all through history, but it was no use trying to destroy them; they must be educated, and that education could be achieved by literature He was sure it was generally felt that ignorance was the great enemy, and he supposed that, if the war could be said to have had any good results, one of those good results was that it had taught people a great deal of history and geography and had brought many nations into contact which had had no connection with one another before that time. It must be remembered that a little learning was a dangerous thing, and there was the danger that people of different nations might only see the superficial characteristics of one another He thought that English people, especially, were liable to dislike people of other nations for the most trivial reasons. To avoid a superficial knowledge of other nationalities it was very useful to have friends of those nationalities to whom one could talk, but as only a few people could enjoy that privilege literature should be employed instead. He thought it was most important for English people to keep in touch with what might be called the Latin tradition, the tradition which had been formed as a heritage from the great system of civilisation which was embodied in the Roman Empire. It was the great misfortune of Germany that she was never conquered by Rome and never entered into that great system of civilisation. In the eighteenth century the relations between England and France were close and constant, and, when that intercourse ceased with the Napoleonic Wars, it seemed to him that the English people clothed themselves in an atmosphere of provincialism which was very regrettable. In conclusion, he wished to thank the author for his admirable discourse

MR. ALAN A. CAMPBELL SWINTON, F.R.S. (Chairman of the Council), proposed a hearty vote of thanks to M Cammaerts for his enthralling address and to His Excellency Baron Moncheur, the Belgian Ambassador, for presiding at the meeting. He was sure everyone present had listened to the paper with close attention and with great admiration, not only for the matter of it, but for the excellent way in which the author was able to address his audience in a language that was not his own

The resolution was carried unanimously

M. EMILE CAMMAERTS, in reply, said he wished to apologise to Dr. Maclean for having omitted any reference in the paper to the very important work of the American Committee in Brussels, and also for not having mentioned the organisation in this country which had been founded to promote friendship between Great Britain and America He wished to thank Mr. Binyon for his charming speech He felt that perhaps he ought to have concentrated more on literature itself in his paper, but he thought it was a mistake for a literary man to deal only with his pet subject, and in the reaction against that natural tendency he had perhaps indulged in rather uncalled for remarks on many other subjects, such as education, in which he was not so directly interested That, however, was simply due to his eagerness to arrive at some practical proposition. The question must be tackled from one side or another, and he ought perhaps to apologise for having tried to tackle it from all sides at once

The meeting then terminated.

THE OLD FAIENCE AND PORCELAIN INDUSTRY OF PROVENCE.

An interesting account of the history of the old Faience and Porcelain industry of Provence has lately appeared in the Nice journal, *L'Eclaireur*. According to this article the chief centres for the production of this class of china ware, were Moustiers, Marseilles and Varanges, with the adjacent village, Javernes. The first, Moustiers, in the Department of the Basses Alps, was established by the two Pierre Clerissy

(uncle and nephew) in 1686, whilst another member of the same family, A. Clerissy, set up a business at St. Jean du Dezert, near Marseilles, in 1695. It was not until some years after that another of the Clerissy family started in 1740 the manufacture of faience at Varanges, in the Department of the Var, which with its neighbour Javernes, soon became famous for the delicacy of design and workmanship of its ware.

The Moustiers china soon acquired fame, not only in France, but even in Spain. A complete dinner service was made to the order of Madame de Pompadour. About this time, taking with him some of the workers from Moustiers, the Duc d'Aranda established in Spain the well-known mark "Alcora," copied from the Moustiers ware.

Soon other distinguished craftsmen entered the field, and the amateur will recognise such names as Pol Roux (1727), Achard, Barbaroux, Berbiguier, Ferroud, Bondil, Combau and Antelmy. Ferrat, Guichard, Langier and Chaix, Mille, Pelloquin and Berge, Tion, Icart and Ferraud, Jean Vizy, Gaspard Viry, Joseph Fouque, Micaud, Gros, together with several members of the Clerissy family, may be noted as the principal artists employed for the decoration of this particular class of ware. The principal mark of the Moustiers china is the letter L, surmounted by an O, in other cases the L is followed by an O, a KL, EFB, AN, ABF, FB. Sometimes it is simply the initial of the decorator, M for Micaud; F, Fouque; T, Tion; G, Guichard; Gros, signed his whole name

The best specimens of the work of the first period, however, are abroad, whilst those of the second, distinguished by a lighter style of decoration, are still to be found in Provence

The fame of the Marseilles-ware is also due to Honoré Savy, who, possessing the secret of a green colour, was enabled to interest the future King Louis XVIII, and obtain for himself the title of "Manufacturer to Monsieur Frère du Roi," together with the right of using the Fleur-de-Lis on his products

The success of this industry stimulated others to enter the field, and in their turn, Joseph with Gaspard Robert, The Widow Perrin, Agnel and Sauze, Fanquier, Jean B Viry, Bonnefoi, Boyer, Leróy set up works of their own and rendered celebrated the mark of Marseilles

The initials A.C., either crossed or separate, are the mark of A. Clerissy, who established the art at Marseilles. Savy, who succeeded him, used a Fleur-de-lis, in three different forms. Joseph Gaspard Robert used three different marks, sometimes the letter R alone, at others with a dot above, or a dot on each side.

Bonnefoi used a B, Leroy an L, Madame Perrin, the initials V.P. (Veuve Perrin) either surmounted by a star, without a star or between two dots.

Certain articles of Marseilles bear in some cases, a flower, a large comma coloured green, blue, black or red, which must not be mistaken for the mark of Chiodo of Savona (Italy.)

Although Varages did not enter into competition with either Moustiers or Marseilles, until considerably later, that is to say about 1746, its products acquired a certain renown Its principal establishments were those of Fabre-Bayol, Richelin, Grosdidier, Montagnac, Laurent and Guigou. The mark is a small cross in black, or A-N.

THE COMMERCIAL SITUATION IN CHINA.

Reviewing a recent report by Mr H. H. Fox, C.M.G., Commercial Counsellor, H.M. Legation, Peking, on the commercial situation in China, the *Board of Trade Journal* of November 3rd says :—

A recent tour of the northern provinces served to strengthen the opinion held for some time past that China, in spite of internal dissensions and misgovernment, in spite of lack of communications and neglect of the scientific development of her vast natural resources, is making slow but real progress, and that she is on the eve of a period of unexampled commercial and industrial development which will in a few years' time bring about a complete change in her economic situation The potential wealth of the country is enormous: China is producing in steadily increasing quantities almost every kind of raw material—animal, vegetable and mineral—known to the world's industries; she is beginning to utilise these materials by manufacturing for herself what she has in the past been obliged to import from abroad. The standard of living all over the country is rising slowly among the mass of the people, very quickly among the educated moneyed classes The Chinese have overcome to a large extent their traditional dislike and suspicion of foreigners and foreign ways, and are rapidly assimilating Western customs and Western modes of living Foreign style goods are ceasing to be luxuries and becoming necessities, and Mr Fox believes that this tendency is to our advantage, and that we shall see that the Chinese, while relying more and more on their own industries to supply the wants that intercourse with foreign nations has created, will purchase far more freely than they have done in the past the better class of goods that they cannot produce at home And in the process of this industrial development there will be a demand for every description of foreign machinery and mechanical appliances which should keep British manufacturers busy for many years to come No marked increase of business in any line can be looked for until there is some improvement in economic conditions throughout the world, but there are grounds

for hoping that for China, at any rate, the worst times have passed; there is a distinct revival in the export trade following on enquiries from Europe and America for China produce, and this has led, as was generally predicted, to the Chinese coming forward and taking delivery of the gradually dwindling local stocks of piece-goods and other commodities, thus clearing the way for new business. It is to be hoped that the disastrous results that followed on the reckless over-trading of 1920 will have taught both foreigners and Chinese a lesson that they will not soon forget, and that buyers and sellers will henceforth conduct their business on less speculative and sounder lines than they, many of them, have done in the past.

Mr Fox's Report (with Appendices) can be obtained from H M Stationery Office, Kingsway, London, W.C. 2

OBITUARY.

ARTHUR WALKER.—Intimation has been received of the death of Mr Arthur Walker, of Whitehaven, who was elected a Life Fellow of the Royal Society of Arts, in 1919. After being educated privately in this country, he was sent to the Moravian School at Neuwied, and he subsequently studied in French Switzerland. He then returned to England and entered the tannery at Whitehaven. In conjunction with his friend, Mr. W. L. Ingle, he investigated the possibilities of many new raw materials and tropical products, and was very successful in opening up fresh business with the colonies.

In 1913, he became a director of the Whitehaven Colliery Company, Limited, and devoted much time to the study of mining problems. He frequently went down the pits, and became extremely popular with the colliers.

GENERAL NOTES.

AMERICAN TRADE COMPETITION IN INDIA.—H.M. Senior Trade Commissioner in Calcutta, Mr T. M. Ainscough, reports that one of the few trades in which the United Kingdom is not entirely regaining its pre-war position in India appears to be that of boots and shoes. Last year America shipped to India £432,200 worth of boots and shoes, as compared with £596,000 from this country. Before the war practically the whole of these articles came from the United Kingdom. The general opinion of a number of importers in India as to the reason for the lack of recovery of British trade in this particular line seems, Mr. Ainscough writes, to be that during the war, the impossibility of obtaining supplies from home compelled the importers to buy elsewhere, and naturally the repeat orders will for some time retard the restoration of British trade. American prices are now considerably higher than British—upon the average 33s 6d. against 16s.—and it seems quite probable that in the near future the main bulk of the trade will return to us "provided that adequate supplies at reasonable prices are obtainable."

"THE PRACTICAL ENGINEER" SCHOLARSHIP.—The Proprietors of *The Practical Engineer* have decided to award a Scholarship in Mechanical Engineering to the value of £30 9s. to a subscriber of The Practical Engineer who shall be adjudged the most suitable candidate. The course comprises a thorough treatment of mathematics, applied mechanics, drawing, steam power and machine design, supplemented by a complete treatise on modern engineering shop practice. It is intended for machinists, toolmakers, pattern makers, foundrymen, blacksmiths, apprentices, draughtsmen, designers, foremen and superintendents. The subjects are treated with special reference to the needs of those engaged, or intending to engage, in machine shop and foundry work and in drawing and designing machinery. Further particulars may be obtained from the Editor, *The Practical Engineer*, 8, Breams Buildings, Chancery Lane, London, E.C. 4.

MODERN INDUSTRIAL ART IN THE VICTORIA AND ALBERT MUSEUM.—The British Institute of Industrial Art is opening an Exhibition of Present Day Industrial Art, to be held, with the sanction of the President of the Board of Education, in the North Court of the Victoria and Albert Museum, from the 16th January to the 25th February, inclusive. The endeavour of the organisers is to bring to the notice of the public the latest productions of both manufacturers and craftsmen. The exhibits are chosen by expert Selection Committees in the various divisions, and consist of the following main sections:—Textiles, Metalwork, Ceramics, Printing and allied industries, and Furniture, the last named being displayed as a series of rooms. On the termination of this Exhibition on the 25th February, the collections will be sent for further exhibition to Bradford, Birmingham, and other important industrial centres. Admission is free, the hours of opening being 10 a.m. to 5 p.m. on weekdays and 2.30 to 5 p.m. on Sundays.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Monday evenings, at 8 p.m.:—

JANUARY 18.—JULIAN S. HUXLEY, M.A., Fellow of New College, Oxford, "Recent Advances in the Determination of Sex in Animals." Peter Chalmers Mitchell, C.B.E., M.A., D.Sc., LL.D., F.R.S., Secretary of

the Zoological Society of London, in the chair.

JANUARY 25.—HOWARD MAURICE EDMUNDS, "Photo-Sculpture." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

FEBRUARY 1.—ARTHUR WILCOCK, "Surface Printing by Rollers in the Wallpaper, Cretonne and other Textile Industries."

FEBRUARY 8.—EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry." SIR ARTHUR DUCKHAM, K.C.B., M.Inst.C.E., in the chair.

FEBRUARY 15.—CLOUDESLEY BRERETON, M.A., Divisional Inspector to the London County Council (Modern Languages), "The Necessity of Speech Training, and the Need of a National Conservatoire."

FEBRUARY 22.—ALEXANDER SCOTT, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum."

MARCH 1.—EMANUEL MOOR "The Duplex-Coupler Piano."

MARCH 8.—W. A. APPLETON, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions." JOHN MURRAY, M.P., in the chair.

MARCH 15.—OSWALD T. FALK, "Certain Aspects of the Problem of Exchange Stabilisation." SIR ROBERT M. KINDERSLEY, K.B.E., in the chair.

MARCH 22.—PRINCIPAL A. P. LAURIE, M.A., D.Sc., F.R.S.E., "The Permanency of Oil Colours."

MARCH 29.—SIR THOMAS OLIVER, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.)

APRIL 5.—JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the chair.

APRIL 26. — PROFESSOR ERNEST R. MATTHEWS, "Sea Encroachment and its Prevention."

Dates to be hereafter announced :—

LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, 'The Natural Power Resources of Ireland."

PHILIP SCHIDROWITZ, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

MAJOR PERCY A. MACMAHON, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock.

JANUARY 27.—ALEXANDER L. HOWARD, "The Timbers of India and Burma." THE RIGHT HON. E. S. MONTAGU, M.P., Secretary of State for India, in the chair.

MARCH 24.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India."

APRIL 28.—F. G. ROYAL-DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the chair.

MAY 26.—PROFESSOR SIR THOMAS W. ARNOLD, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced :—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoon, at 4.30 o'clock.

MARCH 7.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

Date to be hereafter announced :—

LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "Queensland."

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETING.)

Friday afternoon, at 4.30 o'clock.

FEBRUARY 24. PROFESSOR WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., "Brown Coals and Lignites: Their Importance to the Empire."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." Three Lectures.

Syllabus.

LECTURE I.—JANUARY 23.—Historical Introduction—Nature of Inks—Egyptian and Chinese Inks—Modern Carbon Inks—Sepia—Iron Gall

Writing Inks—Methods of Preparation—Properties—Iron Tannates.

Lecture II.—January 30.—Logwood Inks—Vanadium Inks—Aniline Inks—Coloured Writing Inks—Examination of Wri ing Inks—Characteristics of Ink in Writing—Copying Inks.

Lecture III.—February 6.—Marking Inks—Printing Inks—Preparation of Lamp Black—Carbon Blacks—Boiled Oils—Typing Ink—Inks for Miscellaneous Purposes—Secret Writing.

Alan F. C. Pollard, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." Three Lectures.

Syllabus.

Lecture I.—February 20.—Design from the point of view of the User and the Manufacturer—Clerk Maxwell's axioms of Instrument Design—Degrees of Freedom and Constraint—The Six Degrees of Freedom of a Rigid Body—Geometric Design.

Lecture II.—February 27.—The Lower and Higher Pairs—Restraint against Sliding—Restraint against Rotation—Centrodes and Axodes—The Design of Profiles.

Lecture III.—March 6.—The Elastic Nature of all Materials—The Elastic Constants—The Rigidity of nstruments—Manufacture—Models—Interchangeable Manufacture.

Guy Radcliffe, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

Cobb Lectures.

Monday evenings, at 8 o'clock.

F. F. Renwick, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

Monday, January 16 .. Geographical Society, Kensington Gore, S.W., 5 p.m. Mr. O. J. S. Crawford, "The Archæology of the Ordnance Survey Maps."

Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Messrs. E. H. Richards and G. C. Sawyer, "Further Experiments with Activated Sludge."

Tuesday, January 17 .. Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.15 p.m. Mr. H. W. Macrosty, "Some Current Financial Problems."

Metals, Institute of, Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Prof. C. A. Edwards, "The Influence of Time and Temperature on the Properties of Alloys."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Dr. H. S. Stannus, "Demonstration of Arts and Crafts from Nyassaland."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. H. V. Lawley, "Automatic Methods of Kinematograph Film Processing."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. F. H. A. Marshall, "Physiology as Applied to Agriculture." (Lecture I.)

Wednesday, January 18 .. British Academy, at the Royal Society, Burlington House, Piccadilly W., 4.30 p.m. Monsieur Maurice Dounay, "Molière."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. C. W. Saleeby, "The Influence of Light and Air in the Prevention and Cure of Tuberculosis."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. R. Young, "Use and Abuse of Combines and Trusts."

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Meteorological Society, 49, Cromwell Road, S.W., 7.30 p.m. Annual General Meeting.

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Professorial Lecture.

Photographic Society, 35, Russell Square, W.C., 8 p.m. Mr. W. Stoneman, "Faces, Famous, Fair, and Funny."

Microscopical Society, 20, Hanover Square, W., 8 p.m. Presidential Address by Professor J. Eyre, "Microscopy and Oyster Culture."

United Service Institution, Whitehall, S.W., 3 p.m. Colonel Commandant G. A. Weir, "Some Reflections on the Cavalry Campaign in Palestine."

Constructive Birth Control and Racial Progress, Society for, Essex Hall, Strand, W.C., 8.30 p.m. Earl Russell, "Divorce and Birth Control."

Thursday, January 19 .. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Brig. Gen. R. K. Bagnall-Wild, "Aeroplane Installation."

Chromatics, International College of, Caxton Hall, Westminster, S.W., 8 p.m. Miss Louie Bagley, "Painters of Pictures in Sound."

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. 1. Dr. E. M. Delf, "Studies in *Macrocystis pyrifera*, the Giant Alga of the Southern Temperate Zones." 2. Mr. J. L. C. Musters, "The Flora of Jan Mayen Island."

Royal Institution, Albemarle Street, W., 3 p.m. Mr. S. Gordon, "Mountain Birds of Scotland, Sea Birds and Seals." (Lecture I.)

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5 30 p.m.

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Friday, January 20 .. Transport, Institute of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5 p.m. Mr. G. T. Hedge, "The Operation of an Important Railway Goods Terminal."

Metals, Institute of, The University, Sheffield, 7.30 p.m. Messrs. F. C. Robinson and H. G. Dali, "An Investigation of Some Defects in Silver-plating Anodes."

Royal Institution, Albemarle Street, W., 9 p.m. Sir James Dewar, "Soap Films and Molecular Forces."

Victoria and Albert Museum, South Kensington, S.W., 2.30 p.m. Mr. A. F. Kendrick, "English Mediæval Embroideries."

Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. L. Turner, "Geology in relation to Engineering."

University of London, King's College, Strand, W.C., 5 p.m. Prof. R. Robinson, "Orientation and Conjugation in Organic Chemistry from the Standpoint of the Theories of Partial Valency and of Latent Polarity of Atoms." (Lecture I.)

Municipal and County Engineers, Institution of, Plymouth. Conference.

Geologists Association, University College, Gower Street, W.C., 7.30 p.m. Mr. S. Hassledine, "Classifications of the Plaistocene Age."

Mechanical Engineers, Institution of, Storey's Gate, S.W., 6 p.m. Messrs. H. S. Denny and N. V. S. Knibbs, "Some Observations on a Producer-Gas Power Plant."

Saturday, January 21 .. Royal Institution, Albemarle Street, W. 3. p.m. Prof. C. Macpherson, "The Evolution of Organ Music." (Lecture I.)

For Meeting of the Royal Society of Arts see page 159.

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FRIDAY, JANUARY 20, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 23rd, at 8 p.m. (Cantor Lecture). C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." (Lecture I.)

WEDNESDAY, JANUARY 25th, at 8 p.m. (Ordinary meeting.) CAPTAIN HOWARD MAURICE EDMUNDS, M.C., A.M.I.C.E., "Photo-Sculpture." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council in the chair. (The paper will be illustrated with cinematograph views.)

FRIDAY, JANUARY 27th, at 4.30 p.m. (Indian Section.) ALEXANDER L. HOWARD, "The Timbers of India and Burma." THE RIGHT HON. E. S. MONTAGU, M.P., Secretary of State for India, in the chair.

Further particulars of the Society's meetings will be found at the end of this number

COUNCIL.

The Council at their last meeting elected Mr. P. M. Evans, M.A., LL.D., a member of the Council and Vice-President of the Society in place of the Hon. Richard Clere Parsons, M.A., who has been compelled to resign on the grounds of ill-health.

MANN JUVENILE LECTURES.

The second Juvenile Lecture of the course on Clay, given under the Dr. Mann Trust, was delivered by Mr. William Reginald Ormandy, D.Sc., F.I.C., F.C.S., on Wednesday afternoon, January 11th. Mr. Alan A. Campbell Swinton, F.R.S. (Chairman of the Council) presided on the occasion.

Dr. Ormandy said that last week he dealt with the origin of clay and its characteristics, and how its colour varied—in Cornwall being white, in Devonshire yellow, in parts of the Thames Valley red, whilst near London it was quite yellow, owing to the clay becoming mixed with chalk. That afternoon he proposed to tell them something about the properties of clay, and what was done with it, and he was, therefore, bound to introduce a little chemistry. Clay was a combination of silica and alumina. Most sands had a good deal of silica in them which stood fine and high temperatures. An ordinary flame was hardly sufficient to melt it, but skilled glass blowers by the aid of oxy-hydrogen blow-pipes formed it into tubes. Dr. Ormandy illustrated the difference in behaviour between a glass tube and one made of quartz. After being heated in a gas flame and plunged into water the glass tube fell into powder, whilst the quartz tube remained quite intact. Manufacturers, he said, were using quartz vessels as they resisted acids, and chemical apparatus was also being made of quartz because of its property of withstanding a great amount of heat and sudden cooling without cracking. He spoke of the formation of a quartz crystal and explained how it was composed of atoms or molecules arranged like the steps in a spiral staircase. He then dealt with alumina (from which aluminium was made) and showed that there were metals which would burn in water, metal sodium and potassium being experimented with. He mentioned that in his student days the price of aluminium foil was 10s. an ounce, whereas at the present time blocks of aluminium could be had at the rate of 1s. per lb. The foil, he said, was covered with a microscopically thin layer of oxide of alumina, which was obtainable from clay. He pointed out the risk of using a strong soda in cleaning aluminium utensils, and illustrated the action of caustic soda, and water containing a minute quantity of corrosive sublimate, in completely destroying some aluminium foil, although he said, ordinary washing soda or carbonate of soda would

not do them very much harm. He also gave an illustration of the effect of brushing corrosive sublimate upon a sheet of aluminium foil and how the action continued for a long while after the mercury solution had been washed off. A demonstration was also given to show that aluminium would burn, and he stated that aluminium powder mixed with iron oxide forms the metallic iron used for repairing broken tramway lines.

Some interesting experiments were then shewn of the peculiar property clay has of absorbing coloured materials. Clay was added to two solutions of pink and blue, the colours of which were rapidly taken up by the china clay. This, he said, was the principle upon which the coloured crayons of commerce were made. Alumina was also used in the manufacture of the beautiful tints known as lake colours. Porous plates (i.e., plates which has not been glazed) were used in connection with these experiments to receive the coloured clay deposits, and these plates were used by chemists who required something to absorb liquids rapidly; they were also largely used in making electric batteries and appliances in the manufacture of dyes. He referred to the manufacture of hand-made and wire-cut bricks and hand-moulded crucibles, and also described the methods employed in making semi-dry bricks, and glazed tiles, which were compressed clay dust burnt in the kilns to the biscuit form. He also illustrated the action of an electrolyte containing silicate of soda upon a quantity of fairly thick clay, rendering it quite thin, and showed how clay could be deposited electrically like silver and copper by means of electro-osmosis treatment. The water split up the electrolyte into electrified particles, and every little particle of clay took upon its surface one or more charged particles—they ran away from one pole and collected on another. This principle had been utilised for the purification of clay. It was impossible to pour ordinary thick clay into a mould, but by using moulds of plaster of Paris, which sucked up the moisture in the thin clay, they were able to make clay crucibles no thicker than a sheet of writing paper. Teacups, vases, etc., were moulded in the same manner and at a much cheaper rate than was possible by other methods. Crucibles were now being produced in England (which in the course of manufacture, had undergone temperatures ranging from 1.500° to 1,540° C) which were not only equal to but better than anything that had been made in Germany.

Through the kindness of Messrs. Doulton and Co., Ltd., of the Lambeth Pottery, London, to whom the Society and the lecturer are greatly indebted, a demonstration was then given of the use of the potter's wheel for throwing various forms of pottery. Dr. Ormandy said he wished to express his grateful thanks to the many people who had helped him with the lectures, including English China Clays, Ltd., of St. Austell, for all their specimens and for the numerous photographs from which many of his slides were taken; and to the Osmosis Company, Ltd., 36, Victoria Street, S.W., for the loan of apparatus. He also wished to thank Mr. D. Northall-Laurie for his beautiful coloured photographs and expressed his indebtedness to Mr. E. C. Craven, for all the help he had rendered him. He thought they should also pay tribute to Dr. Mann who had bequeathed a sum of money to the Society for the delivery of lectures on scientific subjects to children; a teacher gifted with imagination, he said, could make Science very attractive and lead them into the land of the fairy books.

The Chairman proposed a hearty vote of thanks to Dr. W. R. Ormandy, for his excellent lectures, which was seconded by Sir Herbert Jackson, K.B.E., F.R.S. This was acknowledged by Dr. Ormandy and the meeting then concluded.

PROCEEDINGS OF THE SOCIETY.

SEVENTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 14TH, 1921.

MR. EDWARD DENT, Vice-President of the Society, in the Chair.

TRADE WITH THE NETHERLANDS EAST INDIES.

By SIR WALTER BEAUPRÉ TOWNLEY, K.C.M.G., Minister to the Netherlands, 1917-19.

In order fully to realise the importance of the field for commercial enterprise which we are going to study to-night, it will, I think, be well to first call your attention to the vast dimensions of the Netherland Indian Archipelago, which has a total

area of about 738,000 square miles, and which, if we superimpose it upon the map of Europe, will stretch from the south of Ireland to the east of the Black Sea. Borneo occupies a position about relative to that of the old pre-war German Empire. The curiously shaped Celebes cover a considerable portion of the old Austro-Hungarian Empire, lesser islands are dotted over Roumania and Southern Russia, until finally we come to Dutch New Guinea, which blots out a large part of South-Eastern Russia beyond Odessa. Of this important group of islands Java and Madura, although not the largest in size, have an area of 51,960 square miles and are much the most important from an economic point of view. Out of a gross population of between forty-five and fifty millions, which it is roughly estimated inhabit the entire archipelago, somewhere about thirty-six millions are dwellers in the islands of Java and Madura, which are further much more highly developed than their sister islands.

There is a deal of romance attaching to the early history of the commercial development of the archipelago, when Spaniards, Portuguese, British and Dutch, the great sea-faring nations of the sixteenth and seventeenth centuries, disputed for the trade of the Spice Islands, but the time at my disposal to-night will not permit me to take you through the history of those stirring days which saw the birth of the British East India Trading Company and of the Dutch East India Company within two years of each other in 1600 and 1602.

Except to a comparatively small number of people the trade opening offered by the Netherland Indies was practically unknown until the wants created by the Great War called attention to the fact that these little-known islands could supply many articles of prime importance, such as rubber, sugar, tea, coffee, tobacco, mineral oils, quinine, copra, etc., whilst the spices of the Moluccas, which attracted the venturesome traders of the sixteenth and seventeenth centuries, still have a ready sale, though, of course, an insignificant one compared with some of the products just named.

Very special attention has been paid to the development of the agricultural resources of the Netherland Indian Archipelago. In many cases the colonial administration has assisted to the utmost in the selection and introduction of the various tropical species best suited to the soil and climate of the islands, the products of which may be classified under two heads, what are known as European cultivations and native grown crops. Amongst the former are sugar, coffee, rubber, tea, tobacco, cinchona bark, cocoa and fibres, whilst, in addition to some of the above, rice, coconuts, corn, cassava and peanuts are cultivated by native agriculturists.

Sugar. The cultivation of the sugar cane has greatly developed during the last 25 years; it is entirely confined to Java, and it is claimed that it is now, thanks to untiring systematic scientific research and instruction, the most up-to-date in the world. The area under cultivation has increased 117% in the last 25 years, and the total production of sugar has increased 235% since 1894. It is interesting to note the different directions Java sugar has taken during the last years. In 1874 about 37% went to Holland, the inferior qualities going to England and Asia. From 1895 to 1902 the greater part of the production went to the United States, and from the latter date up to 1914 to East Asia and Australia. During the war years, 1915 up to and including 1917, Europe (chiefly England) and British India, bought the biggest part of the first runnings, but in 1918 China and Japan again became the chief buyers.

Coffee. Various sorts of coffee have been experimented with until experience has proved the Robusta coffee imported from Africa to be the best suited to climatic and other conditions, so that it is now rapidly superseding all other varieties. The production of coffee amounted to 807,290 piculs in 1920, and it is estimated that this year's crop will give a gross total of 985.118 piculs. These estimates anticipate a falling off in the production of all varieties but Robusta.

Rubber. The cultivation of rubber in the Netherland East Indies is of comparatively recent date, but none of the other cultivated products can show such rapid progress. The plantings consist chiefly of Hevea Brasiliensis, which was introduced into Java from the Amazon region in 1876. There are now some 800,000 acres under cultivation on, roughly, 680 estates, of which some 400 are in Java and the remainder in the outlying possessions. Before

the war, the export of this product was chiefly to England and Holland, but during the war years, the United States became more and more the important buyer.

Tea. There are about 220,000 acres under tea cultivation on some 300 estates, of which all but about 30 are in Java, but the cultivation of the plant is being rapidly developed in other islands, and more especially in Sumatra, where it appears to prosper well. In consequence of the unsatisfactory results obtained from the tea seed imported from Assam, the Government decided to establish official tea seed control stations at Tandjong Priok and Belawan Deli. It is claimed that much good has resulted from the measure. Like rubber, and most of the other colonial products tea has been passing through difficult times, but there is every reason to anticipate that these will prove to be only temporary set backs due to the abnormal conditions prevailing as an aftermath of the war. British Netherland Indian tea growers complain bitterly of the 2d. import tax levied in the United Kingdom on all teas other than of British origin. It is claimed that a very large number of the growers are British subjects, and that the tax produces a sum to the Exchequer so insignificant as to be out of all proportion to the irritation it causes, and which may at any time produce unfortunate results. The hostility to the tax seems to be shared by all those who are interested in the tea trade, even by those who are supposed to benefit from it. Efforts to get the tax repealed have failed, but it is to be hoped that its failure to produce any good result may bring about its demise.

Tobacco. The cultivation of tobacco is carried on in Java, both by estates and by the natives, whereas in Sumatra it is entirely cultivated in plantations. Experimental stations for the purpose of giving scientific instruction in the cultivation of tobacco have been established at various places, another instance of the endeavour of the colonial administration to develop on sound lines a product likely to be profitable. Sumatra tobacco is in especial demand and is greatly used as outside wrappers for Havannah cigars. The export of tobacco increased considerably up to 1913, but fell off greatly during the years of war consequent upon the difficulty experienced in the transport trade with Holland, the chief importer both for home consumption and for re-export to Cuba. During the war the U.S., Australia, British India, France and other countries came forward as buyers, but not in sufficient strength to compensate for the loss of the Dutch market.

Coconuts. The plantation cultivation of coconuts has increased during recent years, but compared with the native cultivation, is of small importance. The great demand for vegetable fats has caused renewed interest to be taken in this product. It is said that there were sixty-three million trees in Java and Madoera in 1917, of which over thirty-seven million were fruit bearing, and 44 millions in the other islands, of which 23 million were productive. It is estimated that the product of copra from those trees amounted to almost 368,000 tons in Java and Madura, and to 213,000 tons in the other islands. A large proportion of this was consumed by the natives themselves. Since 1917, the number of copra producing factories has considerably increased, as has the producing capacity per factory, thanks to the use of improved machinery. The factories are now said to be quite modern in their installation, and to be up to the best European and American standards. At the end of 1919, the vegetable oil industry required sufficient raw material for the manufacture of 200,000 tons of copra, apart of course, from that required for native consumption.

Cinchona. This product is very often called Peruvian Bark, a name which of itself shows that we are not dealing with a natural indigenous product of the islands. As its name implies, the cinchona tree, from the bark of which quinine is derived, is a native of South America. It was not imported in any quantity into Java until the year 1854, but the soil and climate of the island proved so suitable for its cultivation, that an almost complete monopoly of production has now been established. Java now supplies about 95% of the world's production of cinchona bark and its derivative, quinine, whilst the export from Peru is almost negligible. This result has, of course, not been reached without diligent work on the part of Government instructors and of the planters. The result of untiring experiments and skilful crossing of various species has shewn that this particular plant can be more successfully grown in Java than anywhere else in the world, including India and Ceylon. In the two last named countries, cinchona cultiva-

tion has given way to tea plantation, presumably because the latter was the more profitable. Efforts are being made to re-establish the cultivation in India and Assam, but even if successful, some years must elapse before the new plantations can come to fruition.

Rice, which is the staple food of the native population, forms the chief crop of native agriculture. The production is enormous, but yet does not, at the present moment, suffice for the demand ; consequently, the export of rice is forbidden, but formerly about 50,000 tons of the superior sorts were exported. Although for this reason rice does not properly enter into our calculations, still, no review of Netherland Indian produce would be complete without some reference to the rice crop, seeing that the harvest of 1919 produced about 7 million tons of padi, equal to about 3½ million tons of hulled rice. This crop was produced on about 3½ million hectares, of which 3 million were irrigated.

Fibres, Indian Corn or *Maize, Cassava,* from which the various forms of tapioca are derived, and *Pepper,* both black and white, are further important articles of export.

The *Oilpalm* is the last cultivated product which need detain us to-night. The latest reports to hand show that the cultivation of the Oilpalm in the Island of Sumatra is increasing on the East Coast and in Acheen, and that efforts are also being made to introduce this cultivation into Java. At the beginning of 1921, there were 12 plantations of about 3,000 hectares actually producing (9,000 hectares have been planted), and the output amounted to 1,719 tons. It is further shewn that exports of palm oil in 1920 amounted to 360 tons, as compared with 180 tons in the preceding year. Holland and Belgium are the chief countries of destination, and more than half the plantations are the property of Belgians and Frenchmen. These figures are small, but it is said that the oil palms flourish well, and when one thinks of what happened in the case of cinchona, one asks oneself whether a somewhat similar development in the cultivation of a tree of such exceptional commercial importance may not occur, without, of course, anticipating that the cultivation of the oil palm in the Dutch East Indies will in any way imperil the future of the oil palm in other countries. So far, the oil palm would appear to have been planted almost exclusively in Sumatra, where the labour question must always be a hindrance to production.

The *Mining Industry* has not made very great headway in the Netherland Indies, although there is reason to believe that a fairly rich future lies open to it. Petroleum and its derivatives are exported in very large quantities, and further oil fields are being continually sought for and exploited. The Anglo-Dutch Petroleum Co. and its affiliated branches have the almost entire monopoly of the industry. The only other mineral product that is at present exported in considerable quantities is tin, which is found in the Islands of Banka and Billiton. There are three coal mines worked by the Government, but the output, which is increasing rapidly, is, so far, consumed in the islands or is used for bunkering purposes, and there is a demand for imported coal.

Business in all the tropical products has suffered severely from the abnormal conditions which have prevailed since the signature of peace. Enormous stocks had been held up in the ports during the war, owing to the shortage of shipping facilities, and as soon as possible they were rushed to the European and American markets, which, having been deprived of them for so long, were in dire need of them and accepted them at abnormal prices. Large fortunes were quickly made, both during this period and while the war lasted, and the jubilant planter thought that the era of unlimited prosperity had dawned at last. The dream, however, was short-lived, and soon the glutting of the buying markets synchronised with the inevitable shrinkage of purchasing capacity due to the financial requirements of all countries to meet the war drainage. The result was that very large unsaleable stocks remained on hand, with the natural resulting fall in prices, which has spelt something like ruin to many. It is probable, however, that in the case of many articles, the present prices are still higher than the pre-war price, though perhaps not sufficiently so to meet the increased cost of production due to higher wages and other causes.

We have seen that the Netherland Indies export many valuable products in varying quantities. Let us now examine briefly what are their requirements which British trade is in a position to supply. There is a large and steady demand for textiles of all sorts, as well as for cement, iron and

steel manufactures, beds, boots and shoes, hats, glassware, earthenware, matches, fancy goods, metals, drugs and chemicals, motor cars, food stuffs, tinned milks, mineral waters, coal, artificial manures, dyes, etc., as can well be imagined when we remind ourselves that we are catering for a population approaching 50 millions, of which many are in affluent circumstances, although, of course, the great majority are of the poorer class with small wants.

Textiles. Taking a 1,000 kilo unit, we find that the total volume of cotton yarns, bleached and unbleached, cotton piece goods, printed or dyed, including manufactured articles such as Sarongs, etc., woollens, half woollens, silk and half silk imported, amounted to 26,283 tons in 1918 and to 43,029 tons in 1920. The value of these imports was respectively 84,340,000 guilders, and 250,407,000 guilders. Great Britain and Japan are the chief exporters of cotton goods to the Netherland Indies in almost equal shares, but Holland also figures as a large exporter with articles which are, for the most part, of English manufacture, a considerable proportion of the British export trade passing through Amsterdam houses. The figures of import values given above are for Java and Madura only, and for the other islands cotton goods to the value of 17,866,000 guilders were imported in 1918, and to the value of 56.710,000 guilders in 1920. The Japanese are very keen competitors for this market, but from the latest information received, it would appear that British goods are decidedly more appreciated by the native population, who are the principal buyers, and that the market is heavily overstocked with Japanese goods for which there is an insufficient demand.

Iron and Steel Manufactures for railway construction, harbour works, irrigation works and all manner of engineering undertakings, are in great demand, and will continue to be so if all the Government Works which are announced in the budget are to be carried out. Independently of these undertakings, there is a large demand for all descriptions of mechanical plant for private concerns. The 1922 Budget is noticeable for its very wide programme of building construction. In accordance with the habitual policy of the colonial administration, it is probable that the contracts for these works will be given almost exclusively to firms established in the islands, but it should be noted that large quantities of building materials will have to be imported.

The statistics for 1919, showing the import to the Netherland East Indies of machines, machinery, machine tools, and all mechanical devices allied to the machinery industry, together with hand tools and agricultural tools, give us a grand total in value of fl53,938,424. Of these goods, to the value of fl20,000,000 were imported from Holland, fl19,000,000 from the U.S.A., about fl10,000,000 from the U.K. and dependencies, and the remainder from various sources, of which the most important were Japan, Australia, Sweden, Switzerland, France and Denmark in the order named. During the first nine months of 1921, the total import of iron and steel manufactures amounted to 737,329 metric tons; of this Great Britain's share was only 71,021 tons, whereas the amount sent direct from Germany during that period was 194,013 tons. Holland supplied 231,486 tons, of which, no doubt, a considerable portion was of German origin, who before the war supplied almost all the tools and implements required for mining and agricultural purposes. The reason for this was largely because German firms held big stocks in spare parts.

Please do not imagine for one moment that the absence of Germany's name from the list of countries I have just read to you implies that she has withdrawn from the market. Quite the contrary is the case. In addition to the customary suppliers before the war, the renowned Hugo Stinnes, who has become to finance and commerce of to-day almost what the bogey-man is to children, has turned his attention to this vast market, which is susceptible of so great development. Thanks to his driving power, a very powerful combine, known as the Rhine-Elbe Union, has been formed, which seems determined, if possible, to capture the entire trade in hardware, if not in other things also, through the instrumentality of the well-known firm of Carl Schlieper, probably the most powerful distributing agency in the archipelago. The Algemeine Electricitats Gesellschaft has been added to the combination, which shows that the Germans are also alive to the possibilities, which are enormous, of the development of electrical power and appliances. The Germans have already secured for themselves a very sound position, as they have entered into an arrangement with the colonial administration, which

has been severely criticised in the Second Chamber of the States General at The Hague, under which, in return for most valuable orders for railway material of all sorts, they have undertaken to establish a factory at Cheribon for the manufacture of iron and steel plant.

This factory will probably prove to be little more than an assemblage works in which parts imported from Germany will be put together, but it will undoubtedly benefit by the favoured treatment which is accorded to industrial undertakings established in the islands. In addition, the German organization has set up large and important offices, on a scale to impress the native with their country's trade position, at Bandoeng, where there is a staff of technical engineers of high standing always on the look out for first news of anything that may come along.

I have not time to-night to go more fully into all the trade openings that offer themselves in this market, but I would call your special attention to the motor industry which has, so far, been greatly neglected, apparently in the belief that the market is already overstocked with cheap American cars. My latest information is to the effect that this is not, in fact, the case, although there are large numbers of such cars, which appear to be almost unsaleable. The truth seems to be that the American car has lost its popularity to no small extent, whilst there is a good demand for the too little known British car. I am not going to trouble you so late in the evening with a list of comparative prices of American and English cars, but I have satisfied myself that some of our new low-priced, but reliably built cars, can very well hold their own—and more—in price with the American variety on the market, and that further, the higher priced and more luxurious car would find ready purchasers among the richer classes. *But*, and this is a big one, the British car, to be a success, must be accompanied with the necessary arrangements for procuring spare parts on the spot. The native buyer will not put his money down for a car unless he can be sure that, in the event of anything going wrong, he can rely upon obtaining the necessary spare part without having to wait weeks or months for it to come from England.

Shipping. No paper dealing with the trade of such a far distant market as this one would be complete without some reference to shipping and harbour facilities. In this connection, it is pleasing to note that the 1922 Budget contains provision for the improvement of the existing ports, and for rendering others more accessible for ocean steamers. It is true that in the past, and I might add up to the present, the ports of the Netherland East Indies were badly equipped to cope with sea-borne traffic. There are those who hold that the four million pounds sterling allotted to harbour works in the 1922 Budget are insufficient for the objects in view, but one must remember that in these days money is not readily come by, and we must hope that these four millions are an earnest of better things to come in the future. The shipping facilities are regular and good, and are being added to, while new ports of call in the islands have been established during the past years, greatly to the advantage of certain districts.

Finances. On the occasion of the Queen's birthday, on the 31st of August last, the Governor General stated that the finances of the country were not critical or dangerous, but, nevertheless, required constant care. This very non-committal statement did not carry the student of the financial situation very far, more especially as the speech was delivered just after a loan of 75 million florins had been successfully floated. The Budget which was issued after a further hundred million State loan had failed of success, bears a rather less optimistic complexion, but on the whole, the situation would not appear to be unfavourable. There has certainly been some rather extravagant administrative financial legislation, founded apparently upon the belief that was generally shared that the high prices after the war had come to stay, but, in the opinion of reliable financial authorities, the burden of debt is not excessive, and no fiscal measures should be needful of a nature to drive away the enterprising spirit of the Dutchman and the foreigner.

Taxation is relatively heavy, and has sometimes been carried out without sufficient regard to the legitimate needs of those who have assisted in the development of the prosperity of the islands, but recent experience has shown that a willing ear is lent to reasonable representations on this head.

I hesitate to abuse the honour done me by the Society of Arts in asking me to read

this paper to you to-night by anything in the nature of propaganda, even for a public institution of such importance as the British Chamber of Commerce for the Island Countries under review, but I have been obliged to cut out much detail, and would only say that anyone who would like to have fuller information upon any point will be welcome at the Offices of the Chamber, where we shall, moreover, have much pleasure in enrolling him as a member.

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said the paper showed how many openings there were for British industry in the Netherlands East Indies, and the sooner they were taken advantage of the better; otherwise the Germans, who had already started their operations there, would extend them still further. One product which had not been mentioned by the author, and which was used a good deal now, was kapok. It grew in Java and Borneo, and was used in life saving apparatus instead of cork In former days there had been a book entitled "Java, or How to Manage a Colony," which had always been looked upon as a standard work in those days. Java, then, had paid a large annual sum to Holland, her surplus revenue being very much more than her expenditure. Now, he believed, it was the other way about. Java had such a large population that her coolies went all over the place. In Borneo they helped to cultivate the rubber there. He agreed with the author that the production of China tea was now dying out; only a very little of the best quality was grown. A large amount used to be made for the Russian market, but now that market was dead, and therefore every year less and less came to this country. He also agreed with the author in regard to the extra 2d. duty which was levied on Netherlands East Indies and foreign tea. It seemed a very small matter and had only been put on during the war to satisfy some people, and he thought it would be taken off in a very short time. Cinchona had been planted in Ceylon, because coffee had at first proved a failure there, and had taken some time to develop, and the planters had grown cinchona as a go-between. Now that tea paid better, the production of cinchona was dying out.

MR. F. C. STOOP thanked the author for the excellent bird's-eye view he had given of the Dutch Indies. Of course, in the space of one hour Sir Walter could not give anything else but a bird's-eye view of the subject; yet he thought the statements made in the paper were quite sufficient to rouse an interest in the minds of those who were not well acquainted with Java and would lead them to a further study of the matter. Java was certainly a most wonderful country. He had not himself been there since 1891, when there were 25,000,000 inhabitants. The last official figure is 36,000,000, which is an immense increase. To show what a remarkable island it is, he might mention that he travelled all through Java, and in one place it had been difficult for his conveyance to find its way through the population. There is a province called Bagelen where the density of the population is greater than in Belgium, which is the most thickly populated country in Europe. That gave a slight idea of the importance of Java. It was not only that the soil in Java is exceedingly fertile and that there is generally water to be had both in the natural way and by irrigation, but Java had at the same time what so many other countries lacked, namely, a very large and very industrious population to help to cultivate the soil. The author had said very little about the other islands comprising the Dutch East Indies. He (the speaker) was a Dutchman by birth, but had lived nearly 50 years in England. He had always remained true to the country of his birth as well as to that of his adoption He felt no jealousy whatever that the author should take such an active interest, through his Chamber of Commerce, in the Netherlands East Indies, and should draw the attention of British traders to the possibilities of Java, because Holland was such a very small country as compared with her colonies in the East Indies that she could not possibly hope to do justice to all that is to be done there, and welcomed the introduction of foreign capital and enterprise.

MR. J M. FRASER said there was very little he could add to the points made in the paper. Of course, in a paper like that which Sir Walter had presented that evening it was not easy to condense the whole volume of trade which it would be possible for Great Britain to do with Java. There were great possibilities in Java, and the audience had heard what the Germans were doing there; but he feared that British manufacturers did not quite realise that it was absolutely necessary to combine and concentrate their whole attention on re-gaining that market. There was a great deal of unemployment in this country at the present time, which, he was afraid, was due to the fact of not having had the right people in Java and on the Continent to represent the British firms. He was largely interested in sugar mills in Java. Up to about 20 years ago the British manufacturer had the monopoly of the machinery for the sugar mills. Then a German manufacturer had sent out a very enterprising commercial traveller. The representative of the British firms was a very nice

gentleman, but he only spoke English. The German representative spoke Dutch, and ingratiated himself with the managers of the sugar mills. On one occasion one of the mills required some new machinery. An offer was received from two British manufacturers quoted in sterling f.o.b. Southampton. On the other hand a slightly cheaper offer was received from the German manufacturer and from another German firm quoted in gilders, delivered at the factory, with a plan of the factory showing how the machinery was going to be put up. Unless British traders would adopt those same methods, he did not think they would beat the Germans The fact must be emphasised to British traders that the men they sent out as commercial travellers to the Colonies and elsewhere must be men that knew the conditions of the country they were going to, and who were able to speak the language; and also British manufacturers must help their men by being willing to take the risk of the exchange and of the freights, and to quote in the currency of the country to which their goods were going.

MR. DAVID LLOYD HOWARD remarked that he had listened with the very greatest interest to the paper, and more so because, as far as the general trade of Java was concerned, he had no personal knowledge whatever. His own experience had been confined solely to the question of Cinchona bark. That product had an intensely interesting history, but it would take up far too much time for him to endeavour to give even a sketch of it at that late hour of the evening. Suffice it to say that quinine, which was made only from Cinchona bark, was one of the most necessary medicines in the treatment of one or more of the various diseases which were known as malaria, and consequently it had played a very important part in the war. The author, who was then Minister at the Hague, knew very well one side of the importance of quinine in the war. He, as a manufacturer of quinine under the orders of the British Government knew the other side, and he only wished he could tell the story; it was a very interesting one. In the latter days of the war, especially when fighting was going on in the Strumitza Valley and also on the Piave Front, which were two of the most pestilential neighbourhoods in the world, quinine became of enormous importance, because it was so obvious that when a man was down with fever it was no use providing him with munitions or anything of that sort; his fever had to be cured first before he could handle a rifle or manipulate a gun. The cultivation of Cinchona in Java gave a very good instance of the wonderful Dutch thoroughness and foresight. It had been a combination of good luck and good judgment—of good luck because among the larger mountains there, there were stretches of soil which were of exactly the right quality, and at the right height, and with the right conditions. The Cinchona Tree was very fastidious, although it could be grown under very various circumstances. For instance, as a little boy he saw it growing in a green-house in Tottenham. But to grow it satisfactorily one had to have exactly the right soil and the right climate. The Dutch were lucky in having the right soil, but it had not been all plain sailing. In the early days they had got hold of a lot of seed which resulted in a very poor type indeed of Cinchona. They had not been content with that, but had looked around and had found better seed. They stubbed up thousands of acres of plantations of the poor stuff and replanted them all with the better stuff, the result being whereas a very fine natural bark from South America would perhaps test 5½ per cent. of quinine sulphate, in the year before the war the average of the whole crop of Cinchona Bark of Java touched 6½ per cent., and he had himself tested samples of Dutch Bark showing 11 per cent. or slightly over.

MR. H. J. DE JONG said he merely desired to make one or two remarks with regard to the exportation from England of goods not only to the Dutch East Indies but to all foreign markets not having English measurements and the English monetary system. He was a Dutchman carrying on business in England—largely an export business, and he found it essential always to quote in kilos. Further, he always made it a point of quoting in particular foreign currency whenever possible. By so doing he had found that he had got trade which firms not willing to follow his example did not get Another point which British firms over-looked was that the buyer abroad liked to be written to, if possible, in his own language. He had found that some foreign buyers were especially sensitive on that point For instance, if one wrote to a Spaniard in French because one did not know Spanish, the odds were that the Spaniard was offended; he would rather be written to in English If Britain would only adopt the decimal system both in coinage and in measurement he thought her trade would benefit largely thereby.

MR. F. B S'JACOB (Dutch Commercial Secretary) thought the whole subject had been so well covered by the author's admirable address that it was almost impossible for him to add anything useful. He might say fiscally the Dutch Indies East and the Mother Country were now entirely separated. That had not been the case, as the Chairman had said, about 50 years ago, but for a long time there had been one Budget for the Netherlands East Indies and another for the Netherlands, and they had nothing to do with each other. Another point he would like to make clear was that the Netherlands East Indies had long adopted the policy of the open door. There were no differential

duties as between goods from Holland or goods from England or any other country, and it was rather a sore point with Dutchmen that in England certain articles produced in Netherlands East Indies were being differentiated against—such as tea and sugar. If those differential duties which had given rise to so much complaint could be done away with in this country, there was no doubt about it that it would be very highly appreciated in Holland and in the Dutch East Indies. He thanked the author for the kind references he had made to the Dutch nation and Government, and could assure him that every Englishman who went to the Dutch East Indies was always an extremely welcome arrival. The more they got the better they liked it, because they had always found in the Dutch East Indies that the Englishman made an extremely desirable colonist, and not a little of the prosperity of the trade of the islands was due to the British firms which had been established there.

MR. W. M. J. WILLIAMS said he had been very much interested in what the author had said about the effect of the preference duty on tea and sugar, and matters of that kind, and he trusted that Sir Walter would use his well-known influence to get that altered. He was quite sure that the people of this country got a very indifferent benefit from that duty. If tea cost 10d. in Assam, then tea coming from Java would cost 1/- according to our law, but the consumer of tea in England did not get that benefit; the difference between the 10d. and 1/- evaporated somewhere else. In the long run, especially at the present time when we wanted more trade, it would be very desirable to see such distinctions blotted out of our tariff.

On the motion of the Chairman, a hearty vote of thanks was accorded to the author for his paper.

SIR WALTER TOWNLEY, in reply, thanked the audience for their kind reception of his paper. The remark made by one of the speakers about the use of languages brought to his mind the fact that some complaints had reached him of the fact that English firms sometimes wrote to the Netherlands Indies in German, and in very bad German too, and such a thing was not liked there.

NOTES ON BOOKS.

A HANDBOOK OF THE BARODA LIBRARY DEPARTMENT. By Newton M. Dutt, Curator of Libraries, Baroda, and Reader to H.H. the Maharaja Gaekwar. Baroda: Central Library, 1921.

In 1909, a series of papers on "The Manufactures of Greater Britain"—the term "Overseas Dominions and Possessions" had not then come into general use—was read before the Royal Society of Arts. One of these valuable papers dealt with industrial India, and the Chairman on the occasion was the Maharaja Gaekwar of Baroda. In the admirable speech he delivered His Highness urged that the "greatest want in India" was education, a want that he has endeavoured to supply so far as his own State is concerned, by bestowing upon it the boon of free and compulsory instruction. The splendid Library Department he has since established as one of the fruits of his frequent travels in the Western world, is further evidence of his zeal in the cause of education and self-culture. He obtained from America the services of an able expert, who was engaged for three years in planning and organising the institution described by Mr. Dutt in his handbook The department includes a fine central library in the capital of the State, aided libraries and reading rooms in a very large number of *mofussil* (country) towns and villages, travelling libraries, a "visual instruction section," which, by means of the cinematograph, lantern slides, etc., caters specially for the non-literate, and training classes for librarians. Another interesting feature is the use that is made of the valuable Sanskrit manuscripts, which have been collected throughout India for the Central Library, namely, the periodical issue of the *Gaekwad's Oriental Series*. Already eighteen volumes have been published, and have gained high praise from scholars like Sir George Grierson, Superintendent of the Linguistic Survey of India, Dr. A A. Macdonell, Boden Professor of Sanskrit at Oxford, and Dr. F. W Thomas, Librarian, India Office. On the shelves of the Central Library are some 89,000 volumes, in addition to 18,000 books set apart for the travelling library. The nucleus of the main collection was formed by the Maharaja Gaekwar's gift of his own private library, consisting of about 20,000 volumes. At present, the Central Library, with the administrative offices, is accommodated in what was formerly the residence of the Maharajas. A new building has been decided upon, the plans of which are being prepared by Sir Edwin L. Lutyens, R.A. Even before the establishment of the Library Department, Baroda was fortunate in possessing an excellent free library, which was founded by His Highness's brother, Shrimant Sampatrao Gaekwad, who for many years has been a Fellow of the Royal Society of Arts.

A COAL MANUAL FOR SALESMEN, BUYERS AND USERS. By F. R. Wadleigh. Cincinnati: National Coal Mining News. In cloth $2.50: in leather, $3.50.

This handbook is designed to meet the needs of salesmen and users of coal. The author describes the various uses of coal and the ways in which it is classified. The principal coal-

fields of the world are next taken, and a list is given of the estimated coal reserves of the principal coal producing countries of the world. The United States head this list with the enormous total of 3,538,554,000,000 tons The methods of purchasing, sampling and analysing coal are discussed, and special chapters are devoted to anthracite, coke, and boilers and furnaces. The final chapter deals with the question of storage and that mysterious phenomenon, spontaneous combustion. How much is known about it may be gathered from this remark of Mr. Wadleigh's: "We can only say that while each kind of bituminous coal has been stored without spontaneous combustion, yet spontaneous combustion has taken place with every kind of coal" Coals of uniform size, free from dust or slack, are generally free from liability to spontaneous combustion, while a mixture of different sizes is more liable to fire than coals of similar size.

The causes leading to spontanebus combustion have never been satisfactorily explained. An interesting article on the subject appeared in this *Journal* on June 20th, 1919, when the author, the late Professor Watson Smith, wrote: "So-called 'spontaneous combustion' arises by reason of such chemical and physical changes in bodies mostly consisting of, or containing carbon (carbonaceous substances), and under the influence of atmospheric oxygen, that sufficient heat is generated to give rise ultimately to combustion." He cites a great many cases in which "spontaneous combustion" has occurred in coal and other substances, and he shows that it has been the cause of great loss of life and of property, both on land and sea.

Interesting as the subject is, however, this is hardly the place to discuss it. Mr. Wadleigh naturally only gives it so much attention as is in proportion to the size of his book, but he gives a list of rules for storing coal which, as he says, "summarise the best practice" They are drawn up by Professor H. H. Stock and Mr. W. D. Langtry, President of the Commercial Testing Company of Chicago, and if they are carefully followed they will do much to ensure safety against this mysterious source of danger.

The handbook contains a great deal of information of much value to all who use coal; while the bibliography at the end of the volume will enable those who so desire to study the subject in greater detail.

COAL TARS AND THEIR DERIVATIVES. By Dr. G. Malatesta. London: E. and F N. Spon, Ltd. 1920. 21/- net.

Here we have a book of 530 + XII large octavo pages, with 180 illustrations. It is translated from the Italian, by a translator whose name does not appear, but the title page informs us that it embodies revisions, corrections, and additions by the author.

The notable and characteristic merit of Dr. Malatesta's work in its original Italian form, is the full and exact delineation of notable tar and tar-products' plants, and the exactness of the descriptions. The drawings, many of which show remarkably full details, are reprinted in the translated version now before us, and we may especially refer to page 141 on which is a highly complex drawing illustrating the plant for the Coppée method of condensing and separating the tar products which are generated in the manufacture of furnace coke: the details being further elucidated by the figures on the two following pages As part of the sequence of these drawings there are about fifty descriptive words or sentences, but all these are the original Italian. As the understanding of the drawings depends largely on these words or sentences, it seems remarkable that English expressions were not substituted, as we may take it that some readers— and possibly many— may be troubled by the absence of translation.

Further we must say that we are not fully satisfied with the translation of the general text as it appears to have been made by one not having a very thorough knowledge of the delicacies of the English usages and idiom, or possibly the final reading at the office of the publishers may have been somewhat hurried.

"Like a house on fire" (p. 3) is not a very happy literary simile for rapid industrial progress. "Recovered" (3rd line from end, p. 37) does not quite correspond to the English sense and moreover the sentence in which it is used, rather suggests Italian in English words than well reading English: further, the description of ash-determination (p 508) may embarrass many readers, or even be wholly unintelligible to some.

Dr. Malatesta's work has many merits, one being the numerous references to sources and authorities; but English chemists who revere the memory of our pioneer workers would rather see a mention of Greville Williams in connection with picoline, than the suggestion of two personalities as embodied in the expression "Greville and Williams" (pp 276 and name index).

OIL SHALES By H. B Cronshaw, B A, Ph.D, A.R S M. London · John Murray. 5s. net.

In this monograph, which forms one of the series produced under the direction of the Mineral Resources Committee of the Imperial Institute, the author first describes oil shale and the similar material torbanite; the mining and distillation of oil shale, and the composition and properties of oil shale. He next deals with deposits of oil shale and torbanite in various parts of the British Empire, including those in the Utrecht district of Natal, Wakkerstroom district of the Transvaal, Albert County in

New Brunswick, Pictou County in Nova Scotia, Blue Mountains in New South Wales and Mersey district in Tasmania. Accounts of foreign deposits are given, and include those of the United States, France, Bulgaria and Brazil. A map showing the oil shale deposits of the world, and a bibliography conclude the volume.

GENERAL NOTES

THE INSTITUTION OF ELECTRICAL ENGINEERS: COMMEMORATION MEETING.—For the purpose of commemorating the first meeting of the Society of Telegraph Engineers, which was held on the 28th February, 1872, the Council of the Institution of Electrical Engineers (originally the Society of Telegraph Engineers) are arranging for the following Institution Meetings to be held on dates approximately corresponding to that of the original meeting :—*Tuesday, 21st February, at 4 p.m.* Popular Lecture (admission by ticket, a limited number of seats being reserved for guests) by Professor J. A. Fleming, F.R.S., on "Michael Faraday and the Foundations of Electrical Engineering." *Tuesday, 21st February, at 7 p.m. (for 7.30 p.m.)* Annual Dinner at the Hotel Cecil. *Wednesday, 22nd February, at 8.30 p.m.* Professor Fleming will repeat his Lecture of the previous day. *Thursday, 23rd February, from 4 to 6 p.m., and from 8 to 10 p.m.* A number of members of the Institution and others closely connected with the early development of Electrical Engineering will give short discourses on their reminiscences and experiences during the early history of the Electricity Supply Industry. The speakers will deal both with matters of scientific and technical interest and also with the effect of legislative action on the progress of the industry.

OIL SEED PRODUCTION IN INDIA.—In normal years, writes the United States Trade Commissioner in India, that country produces some 5,000,000 tons of oil seeds, worth about £50,000,000, one-third of which is usually exported. No other country produces such a variety, which includes cotton seed, rape seed, peanuts, sesame seed, mowra seed, poppy seed, niger seed, linseed, castor seed, as well as copra. Linseed, niger seed, and poppy seed were formerly used in paints and varnishes as liquid drying oils, and rape seed was employed for industrial purposes, but linseed and rape seed can be refined for the production of margarine, and much rape seed is being used for this purpose on the Continent of Europe. Copra and mowra yield solid fats, while liquid non-drying oils are expressed from cotton, sesame, rape, and castor seed, and from peanuts. India furnishes 98 per cent. of the castor seed of the world, the oil from which is considered the best lubricant for aeroplane engines, and also supplies 100 per cent. of the mowra, 100 per cent. of the niger, 65 per cent. of the rape, and 76 per cent. of the poppy seeds of the world.

PHYSICS AND CHEMISTRY OF COLLOIDS.—A report of a discussion on the above, held jointly by the Faraday Society and the Physical Society of London, in 1920, has been published by the Department of Scientific and Industrial Research, on account of the exceptional scientific and industrial importance of the questions discussed. The contents include an Introduction, consisting of the papers, "A Short Survey of the Physics and Chemistry of Colloids," by Professor The Svedberg, and "The General Structure of Colloids," by Dr. Wolfgang Pauli, and papers and discussions under the following headings :—Section 1.—Emulsions and Emulsification. Section 2.—The Physical Properties of Elastic Gels. Section 3.—Glass and Pyrosols. Section 4.—Non-Aqueous Colloidal Systems. Section 5.—Precipitation of Disperse Systems. Section 6.—Electric Endosmosis and Cataphoresis. Two appendices are also included, No. I, "The Proteins and Colloid Chemistry," by Jacques Loeb, and No. II, "On the Internal Pressure of Liquids," by H. Kneebone Tompkins. Many of the leading European authorities on this subject contributed to the proceedings of the conference.

THE WOOLLEN INDUSTRY OF JAPAN.—The Japanese woollen industry is still virtually in its infancy, its growth having been greatly hindered by war conditions, which made it practically impossible for the requisite material to be secured. Substantial encouragement for development is, however, being given by the Japanese Government. The Government itself is a very large owner of the various kinds of machinery used in the manufacture of woollen goods, and this machinery is being loaned out, at a nominal charge, to private undertakings engaged in or taking up the industry. A further measure of help is in the form of exemption from taxation—every new woollen manufacturing enterprise being free from taxation during the period of its first two years' operation.

AEROPLANES AS SCARECROWS.—In order to prevent the great damage done by ducks on the Californian rice fields, an aeroplane patrol was established to fly over the fields and scare away the birds. This system was started in 1919, and was so successful, according to *California Fish and Game*, that now five aeroplanes are kept busy, making both day and night flights to frighten off the wild ducks. But while the farmers are highly pleased, the American Game Protection Association is greatly perturbed on account of the number of birds killed by striking the propellers and guy ropes, and it has demanded that the permits for the use of aeroplanes for this purpose should be revoked.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. :—

January 25.—Howard Maurice Edmunds, "Photo-Sculpture." Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the chair.

February 1.—Arthur Wilcock, "Surface Printing by Rollers in the Wallpaper, Cretonne and other Textile Industries." Sir Cecil Harcourt Smith, C.V.O., LL.D., Director of the Victoria and Albert Museum, in the chair.

February 8.—Edward Victor Evans, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry." Sir Arthur Duckham, K.C.B., M.Inst.C.E., in the chair.

February 15.—Cloudesley Brereton, M.A., Divisional Inspector to the London County Council (Modern Languages), "The Necessity of Speech Training, and the Need of a National Conservatoire." Sir Henry Newbolt, C.H., D.Litt., LL.D., Chairman of the Departmental Committee on the Teaching of English, in the chair.

February 22.—Alexander Scott, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum."

March 1.—Emanuel Moor, "The Duplex-Coupler Pianoforte."

March 8.—W. A. Appleton, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions." John Murray, M.P., in the chair.

March 15.—Oswald T. Falk, "Certain Aspects of the Problem of Exchange Stabilisation." Sir Robert M. Kindersley, K.B.E., in the chair.

March 22.—Principal A. P. Laurie, M.A., D.Sc., F.R.S.E., "The Permanency of Oil Colours." Sir Aston Webb, K.C.V.O., C.B., P.R.A., in the chair.

March 29.—Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.)

April 5. — Professor Ernest R. Matthews, "Sea Encroachment and its Prevention."

April 26.—John Francis Crowley, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." Sir John F. C. Snell, Chairman of the Electricity Commissioners, in the chair.

Dates to be hereafter announced :—

Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

George Fletcher, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

Philip Schidrowitz, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

Indian Section.

Friday afternoons at 4.30 o'clock.

January 27.—Alexander L. Howard, "The Timbers of India and Burma." The Right Hon. E. S. Montagu, M.P., Secretary of State for India, in the chair.

March 24.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India."

April 28. — F. G. Royal - Dawson, M.Inst.C.E., "The Need for an All-India Gauge Policy." Sir Robert Woodburn Gillan, K.C.S.I., LL.B., in the chair.

May 26.—Professor Sir Thomas W. Arnold, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced :—

J. T. Marten, I.C.S., M.A., "The Indian Census."

Dominions and Colonies Section.

Tuesday afternoon, at 4.30 o'clock.

March 7.—Major Sir Humphrey Leggett, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

Date to be hereafter announced :—

Lieut.-Colonel Sir Thomas Bilbe Robinson, G.B.E., K.C.M.G., "New Zealand."

Dominions and Colonies and Indian Sections.

(Joint Meeting.)

Friday afternoon, at 4.30 o'clock.

February 24. — Professor William Arthur Bone, D.Sc., Ph.D., F.R.S.,

"Brown Coals and Lignites: Their Importance to the Empire."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." Three Lectures.

Syllabus.

LECTURE I.—JANUARY 23.—Historical Introduction—Nature of Inks—Egyptian and Chinese Inks—Modern Carbon Inks—Sepia—Iron Gall Writing Inks—Methods of Preparation—Properties—Iron Tannates.

LECTURE II.—JANUARY 30—Logwood Inks—Vanadium Inks—Aniline Inks—Coloured Writing Inks—Examination of Writing Inks—Characteristics of Ink in Writing—Copying Inks.

LECTURE III.—FEBRUARY 6.—Marking Inks—Printing Inks—Preparation of Lamp Black—Carbon Blacks—Boiled Oils—Typing Ink—Inks for Miscellaneous Purposes—Secret Writing.

ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." Three Lectures. February 20, 27 and March 6.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

COBB LECTURES.

Monday evenings, at 8 o'clock.

F. F. RENWICK, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, JANUARY 23..British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Prof. W. Rothenstein, "Architectural Draughtsmanship."
East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Mr H. E. A. Cotton, "Castes and Customs in Malabar."
Mechancial Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Meeting). Mr. F. A. Best, "Airships."
Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Mr. S. T. Klein, "The Invisible is the Real, the Visible is only its Shadow."
Geographical Society, 135, New Bond Street, W. Mr. E. J. Edmonds, "Luristan."
Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. Dr. H. H. Poole, "Some Notes on the Distribution of Activity in Radium Therapy under different conditions of Screening."

TUESDAY, JANUARY 24..Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. 1. Mr. A. W Rebdell, "Control of trains, in relation to increased weight and speed combined with reduced headway." 2. Sir Henry Fowler and Mr. H. N. Gresley, "Trials in connection with the Application of the Vacuum-Brake for Long Freight Trains."
Photographic Society 35, Russell Square, W.C., 7 p.m. Mr C. M. Thomas, "The Plate and the Photographer."
Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Mr. G. Collingwood, "Hadrian's Wall: a History of the Problem."
Anthropological Institute, 50, Great Russell Street, W C., 8 p.m. Anniversary Meeting.
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p m. Rev. Dr. G. E. Lloyd, "British Emigration and the Future for Western Canada."
Royal Institution, Albemarle Street, W., 3 p.m Dr. F. A. H. Marchall, "Physiology as Applied to Agriculture." (Lecture II.)

WEDNESDAY, JANUARY 25 . Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Mr. A. C. Inman, "Laboratory Aids to the Diagnosis of Tuberculosis Infection."
Oriental Studies, School of, Finsbury Circus, E C., 12 o'clock Miss Alice Werner, "Bantu Mythology and Folk Lore." (Lecture I) 5 p.m. Mr. A. Sabonadière, "Some Cases I have Tried."
Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p m. Mr. F. Hughes, "Conditions of Industrial Harmony."
Literature, Royal Society of, 2, Bloomsbury Square, W C, 5 p.m Marquis of Crewe, "Some Writers on English Country Life."
United Service Institution, Whitehall, S.W., 3 p m. Major-General W. H. Anderson, "The Crossing of the Canal du Nord by the First Army"
University of London, University College, Gower Street, W.C., 5 p.m. Mr H. G. Spearing, "The Palace of Minos."
Civil Engineers, Institution of, 9, George Street, S.W. 6 p.m. (Students' Meeting). Mr W. E Monkhouse, "The Economic Aspects of Various Methods of Power-Transmission"

THURSDAY, JANUARY 26 . African Society, at the ROYAL SOCIETY OF ARTS. John Street, Adelphi, W.C., 5 p.m.
Microscopical Society, 20, Hanover Square, W 7.30 p.m (Metallurgical Section). Mr. H. Wrighton, Demonstrations of Polishing Metal Specimens.
Mechanical Engineers, Institution of (Midland Branch), The University, Birmingham, 7.30 p.m. Mr. J. D Morgan, "High Tension Spark Ignition in Internal Combustion Engines." (North-Western Branch) Memorial Hall, Albert Square, Manchester, 7 p m.
Royal Society, Burlington House, Piccadilly, W, 4 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p m.
Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr E. B. Moullin, "Capillary Canals in Concrete and the Percolation of Water through them."
Royal Institution, Albemarle Street, W., 3 p m. Mr. Seton Gordon, "Sea Birds and Seals." (Lecture II.)

FRIDAY, JANUARY 27..Royal Institution, Albemarle Street, W., 9 p.m. Viscount Burnham, "Journalism."
Engineers, Junior Institution of, 39, Victoria Street, S.W., 8 p.m. Mr. L. M. Jockel, "Fuels and the Boiler House."
Physical Society, Imperial College of Science, South Kensington, 5 p.m.

SATURDAY, JANUARY 28..Royal Institution, Albemarle Street, W., 3 p.m. Dr. C. Macpherson, "The Evolution of Organ Music." (Lecture II.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 173.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 30th, at 8 p.m. (Cantor Lecture). C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." (Lecture II.)

WEDNESDAY, FEBRUARY 1st, at 8 p.m. (Ordinary Meeting.) ARTHUR WILCOCK, "Surface Printing by Rollers in the Cotton Industry: A comparison with other Processes of Printing Patterns for Cretonne, Dress Materials, Wall Papers, etc." SIR CECIL HARCOURT SMITH, C.V.O., LL.D., Director and Secretary, Victoria and Albert Museum, in the chair.

DOMINIONS AND COLONIES SECTION.

A meeting of the Dominions and Colonies Section Committee was held on Monday, January 16th.

Present:—Major Sir Humphrey Leggett, D.S.O., R.E., in the chair; Mr. A. H. Ashbolt (Agent-General for Tasmania); Hon. Sir James Daniel Connolly (Agent-General for Western Australia); Sir Charles H. T. Metcalfe, Bt., Mr. F. C. Wade, K.C. (Agent-General for British Columbia); and Mr. George Wilson, C.B., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Dominions and Colonies and Indian Sections).

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING

WEDNESDAY, JANUARY 18th, 1922.

PETER CHALMERS MITCHELL, C.B.E., M.A., D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Ainsworth, E., London.
Anderson, Roy King, Bassein, Lower Burma.
Ashworth, Sidney Herbert, A.I.Mech.E., V.D., Naihati, Bengal, India.
Bando, S. N., B.Sc., Calcutta, India.
Brooks, Milton, Calcutta, India.
Chak, Pandit Sangam Lal, Lucknow, India.
Choudhari, Dhanji Garbad, London.
Desai, Gapaldas Viharidas, Gujerat, India.
Douglas, Frederick William, B.A.Sc., A.M.E.I.C., New York City, U.S.A.
Hall, Wilfred, B.Sc., Tynemouth.
Murphy, Walter P., Chicago, U.S.A.
Nelson, Frank, Bombay, India.
Nichols, Ronald Herbert, Kulti, Bengal, India.
Oughton, Ernest, O.B.E., M.Inst.M.M., Hindubagh, Baluchistan, India.
Piggott, Leonard Charles, F.R.G.S., Buxton, Nr. Norwich
Pratley, Philip Louis, M.Inst.C.E., Quebec, Canada.
Sherman, Major Norman Clarence, Esquimalt, B.C., Canada
Soundy, L. H., London.
Tait, Louis Benjamin, Rangoon, Burma.
Taylor, S. H., Cawnpore, India
Thaker, Narmadashanker Ganpatram, Ahmedabad, India.
Vernon, George Shirra Gibb, Calcutta, India
Walker, Herbert Wilson, Seascale, Cumberland.
Warburton, Walter Granville, O.B.E., J.P., Bombay, India.
Wicksteed, Henry K., B.A.Sc., M.E.I.C., Toronto, Canada.
Yabsley, Percy, Aylesford, Kent.

The following candidates were balloted for and duly elected Fellows of the Society:—

Hopkins, James Love, LL.B., St. Louis, U.S.A.
Ruddick, James, Quebec, Canada

The CHAIRMAN, in introducing the lecturer, said that he was the grandson of Thomas Henry Huxley, one of the greatest figures in the history of British biology; that he had voluntarily resigned a professorial chair in the United States, and returned to serve his country with distinction during the war, and that, by his investigations at Oxford, he was rapidly gaining a reputation as one of the rising younger men of science.

The paper read was :-

SOME RECENT ADVANCES IN THE BIOLOGICAL THEORY OF SEX.

By JULIAN S. HUXLEY, M.A.,
Fellow of New College, Oxford.

It is with some misgivings that I have chosen as my subject one which is so intertwined with our whole existence, physical and mental, as that of sex. There is a mystery about the simple fact of sex which rivals the mystery of life itself. It may, I suppose, occur that certain individuals and certain races take sex as given, and bother their heads no further with it. But once the attention of the human mind has become entangled with the problem, unsatisfied wonder and curiosity are begotten, and in their turn beget a varied progeny of myth and tabu, of legend and doctrine.

It is impossible to touch on many of the points that arise. The latter-day psychologists have shewn us how primitive instincts, such as those of fear and of sex, wind themselves round the roots of all mental life, become sublimated by the acquisition of new objects, and are parts of the indispensable subterranean driving force of mind.

The evolutionists have given us a glimpse of the secondary changes which sex has wrought in the history of life. Given separate male and female organisms on the one hand, and a certain level of mental organisation on the other, there will follow, as a result, a need for stimulation of one sex by the other. This, in its turn, will lead to the development of striking and beautiful colours and structures, sounds and displays, either in one or in both sexes. Through this machinery of cause and effect, sex has led to the establishment in animals of all that beauty of form, colour, and voice, which is not the product of mere regularity and symmetry, of a sense of speed or power, or of the fitness of a structure for its purpose.

With this side of the problem, however, we cannot here deal. We are to concern ourselves with the subject of sex-determination, a subject which is not only of interest for its practical bearings, but because it is a focal point where cytology, genetics, pure zoology, embryology, and physiology meet, and because it promises to throw valuable light upon all these branches of biological science.

I may be pardoned if I begin by running over a few fundamental facts. All organisms, then, are composed of one or a multitude of cells (if we omit the bacteria, whose organization cannot properly be called cellular). Each of these cells consists essentially of a mass of living substance, containing a nucleus, also of living substance, but of a special nature. Whenever the cell divides—and growth in higher organisms is in the main a matter of cell-division—the nucleus resolves itself into a number of denser bodies, the so-called chromosomes, whose number and shape are constant for each different species. Each of these divides longitudinally when the cell divides, and one half of each passes into each daughter cell.

The essential sexual act is the union of the nuclei of two cells. Usually these cells - styled gametes or marrying cells—are of two kinds, male and female, the male cell or spermatozoon being generally small and active, the female cell or ovum being large, passive and full of reserve food substances. But in many of the lowest forms of life the gametes are almost or quite alike; thus at the outset we are met by the apparent paradox that a difference between two sexes is not implied by the existence of sexual fusion. The paradox comes from the historical fact that sex-difference was recognised before the nature of sexual fusion was understood or even discovered, and that, consequently, the word sex etymologically implies a difference.

The problem of the value of sex to life is on the way to a definitive solution. We find that the primitive form of reproduction in organisms is asexual—the creature divides into two, or buds its offspring. The sexual act, in the simplest forms, is a total fusion of two individuals, and, far from being subservient to reproduction, stands in its way. During the time that it takes, two or three asexual generations might have been produced.

What advantage, we immediately ask, is conferred by this sexual fusion that can compensate for the delay it causes in the process of reproduction?

Once more we must return to fundamentals. Genetical research since the rediscovery of Mendel's laws has made it increasingly certain that all, or almost all, of the hereditary constitution of an animal or plant consists of a series of actual chemical unities, the hereditary

factors or genes. Furthermore, we can be almost certain that these factors, whose existence we must predicate from our breeding experiments, are actually lodged in the chromosomes of the nucleus, where each one has its appointed station.

In a sexually-reproducing organism, these factors are always (with certain later-to-be-mentioned exceptions) present in duplicate; one member of each pair has come from the father, one from the mother. When the time for reproduction is approaching, the chromosomes arrange themselves in pairs, and at one particular cell-division the two members of the pair separate undivided from each other, so that each gamete has half the number of chromosomes characterising the species.

This is known as the reduction-division. There are details associated with it into which we cannot enter here; but for our purpose the nett result of the process is roughly that every gamete contains one or other, but never both, of every pair of hereditary factors in the organism's constitution.

It should be noted that whereas in the male all the cells produced become functional male gametes or sperms, in the female this is not the case. The female gamete, or ovum, must be large in order to start the developing embryo quickly and efficiently on its way. Its growth period occurs before the last two cell-divisions; and, so, in order that it may retain a respectable size, these last divisions are unequal, first one and then a second minute cell being separated from a much larger cell. The small cells are called the polar bodies, and speedily degenerate: the large cell remains to function as the ovum. One of the two divisions leading to the polar body formation is the reduction division.

The sets of factors are like packs of cards, and each organism is given two packs with which to play the game of life. But while the ordinary pack has fifty-two cards, the different hereditary factors are to be numbered certainly by hundreds, or more likely by thousands. Each card of an ordinary pack has a fixed value; a king is always a king, a ten always a ten. But here the cards may vary, or mutate, as we say; and the variation may be of such a nature that the card is of more value or of less value in the game which is life. It is, in fact, through the selection of these variations, by the preservation of some and the dropping out of others, that life advances along the evolutionary road.

Now when sexual fusion occurs, the two packs of factors are separated from each other, each gamete receiving a single pack. One pack came originally from the father, one from the mother. But the redistribution to the gametes is at random; so long as one whole pack goes to each gamete it is no matter how many of its component factors come from the father, how many from the mother. Thus, with the great number of factors in each pack, it is extremely unlikely that any two gametes will be identical in the factors they receive.

Here is the key to our first riddle of sex. If there were no sexual fusion, the factors, in the longitudinal splitting of the chromosomes, would each be divided at every cell division, and parent and offspring would be identical save for rare aberrations of division. When a variation arose it would be propagated further; but it could not be recombined with another variation arising in another stock. Where there is sexual fusion, however, there is a ceaseless shuffling and re-dealing of the factors. The union of gametes from two separate stocks can recombine variations which have arisen independently in time and remotely in space. If the two variations are both favourable and reinforce each other, the possessors of both will be given great advantage in the struggle for existence.

In brief, the evolutionary responsiveness of a race, its plasticity, is enormously increased through sexual fusion.

Two of the chief theories held in the past as to the rôle of sex have been diametrically opposed to each other; one maintaining that sex made for rapid evolutionary change, the other that it ensured stability. Both are, as a matter of fact, in their way correct. Changes occurring in the constitution of some members of a species can, through sexual fusion, be commingled with the changed factors from other regions, and so the more or less accidental crystallizing-out of special sub-races, elementary species and local varieties may be prevented, or, at least, delayed. On the other hand, if the environment is changing, sexual fusion will permit of the combination of any new variations that may crop up, and so permit of a far more rapid change than does asexual reproduction. Put mathematically, if n inventable variations occur in a given

period, then with asexual reproduction *n* different types are possible; but with sexual fusion, 2^n different types.

Sex is the basis of evolutionary plasticity for all organisms of a complexity great enough to demand a complicated hereditary constitution comprised of many unit factors.

The bacteria possess no nucleus, no chromosomes, they appear to be so simple that they need no such regulatory mechanism of heredity. In consequence, they are sexless. In all other groups of organism, so far as known, sex is found. Some individual members of certain groups seem to have abandoned sex altogether; bananas, for instance, are propagated entirely by vegetative methods. Other species are hermaphrodite, and practise continual self-fertilization; these have abandoned, not sex itself, but all the evolutionary value of sex, since in them there is no crossing of stocks.

In the vast majority of organisms, however, crossing of stocks does occur; and in many plants and in the majority of animals, the male and female gametes are produced by separate individuals—there are what we call two separate sexes. The problem is presented, in all such forms, of maintaining these two kinds of individuals, in approximately constant proportions, within the single species. The males of a species are often far more different from the females than they are from the males of related species or even of related genera or families. How can the single biological unit of the species exist under this double form?

Analogies are to be found. The common primrose, for instance, is found in two forms, the one pin-eyed with long style and short anthers, the other thrum-eyed, with the style and anthers in the reverse position; this dimorphic condition is of advantage, as Darwin long ago pointed out, in securing cross-fertilization. Breeding experiments carried out by Bateson showed that the constant presence of these two

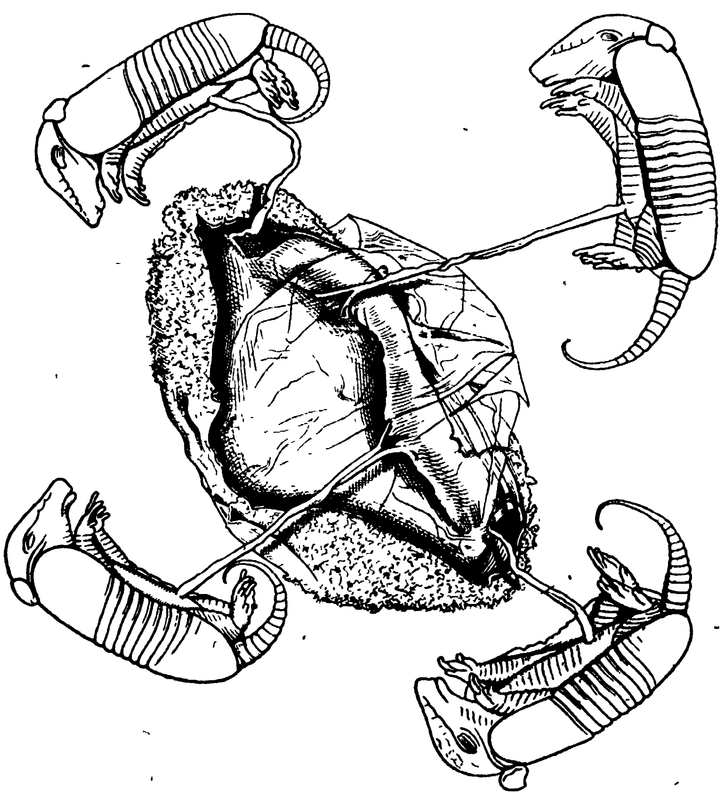


FIG. 1.—Nine-banded Armadillo (*Tatusia novemcincta.*) Four foetuses attached to one placenta and derived from one ovum. (From a specimen presented to the Cambridge Museum by Dr. H. H. Newman.)

types within the species was ensured by the simple device of having one type usually hybrid or impure, or, in the jargon of mendelism, heterozygous.

Short-style (call it S) is dominant to long-style (call it s). Long-style plants are ss in constitution; most short styled plants are Ss, and will form S-bearing and s-bearing gametes in equal number, whereas all the gametes of the long-styled plant will bear s. Thus combinations s and s (or long-style) and s and S (or short-styled) will be produced in equal numbers in the next generation.

We must remind ourselves at the outset that various facts of general biology speak strongly for the view that sex in the higher animals is usually predetermined at the moment of fertilization. The best evidence on this point is afforded by the study of twins. Human twins may be no more alike than are ordinary brothers and sisters, and if so may be of opposite sexes; or, in the case of so called identical twins, they may be so alike that confusion is possible between them, and if so are always both of one sex. When this is so there is evidence, drawn from the embryonic membranes, that both members of the pair have been derived from a single fertilized ovum. In animals, members of the same litter are usually twins of the first type, without special resemblance; but in the Texas Armadillo, it has been found that the four young invariably produced at a birth always show the closest resemblance to each other, always are of the same sex, and always have a common embryonic membrane. The researches of Newman have finally shown that the four are actually budded out from an originally single embryo at a very early stage of development.

It thus appears certain that identical twins are produced by the division, normal or accidental, of a single fertilized ovum, while other twins are products of separate sets of sexual fusion. Both kinds of twins are subjected to identical condition in the mother's uterus, and yet only twins derived from one ovum are usually of the same sex.

What is it in the fertilized egg which thus appears to determine the sex of the embryo arising from it?

Some twenty years ago, an American zoologist noticed that the chromosomes of various insects differed in the two sexes; the male had one less than the female. Later work has shown that there is, as a matter of fact, a similar sexual difference in the chromosomes of a large number of animals. The simplest form of difference is the total absence of one chromosome from the constitution of the male.

The chromosomes in which the sexual difference is found are usually designated sex or better X-chromosomes. The female then possesses a pair of X's, the male but one. In other species, while the female is of similar constitution, two unlike chromosomes, called X and Y, are present in the male.

It was speedily pointed out that these chromosomes would provide a mechanism for sex-determination. If, for instance, (as in some flies) the female is XX, the male XY, then all the female gametes will contain X; but half the male gametes will contain X, the other half Y. If the first class of male gametes fertilize an egg, the resultant individual must be XX—*ergo* female; if the second, the offspring must be XY—*ergo* male.

Similar reasoning will apply to those species in which the male X chromosome has no mate. These types of sex-chromosomes, as they are called, are found in most insects, and in mammals, while a variation occurs in certain worms. The precise reverse—where the male has a pair of similar chromosomes, the female a dissimilar pair or but a single one—is to be found, strangely enough, in one whole group of insects, the butterflies and moths, and in birds.

If the factors of heredity are in reality borne in the chromosomes, and the factor for sex is in some way located in the X chromosome, then it is clear that in all animals with sexual differences in their chromosomes, one sex is pure or homozygous for the sex-factor contains it in double dose; while the other is impure, heterozygous, and we have a real parallel with the case of the Primrose.

The supposition that the sex-factors are as a matter of fact lodged in the X chromosomes, has received strong support from breeding experiments.

It has for long been known that the inheritance of certain characters is what is known as sex-linked. Such a character, for instance, is the human disease known as hæmophilia, or excessive bleeding. Bleeders are almost invariably males; but they always inherit their dispositions to the disease through their mothers. Many precisely

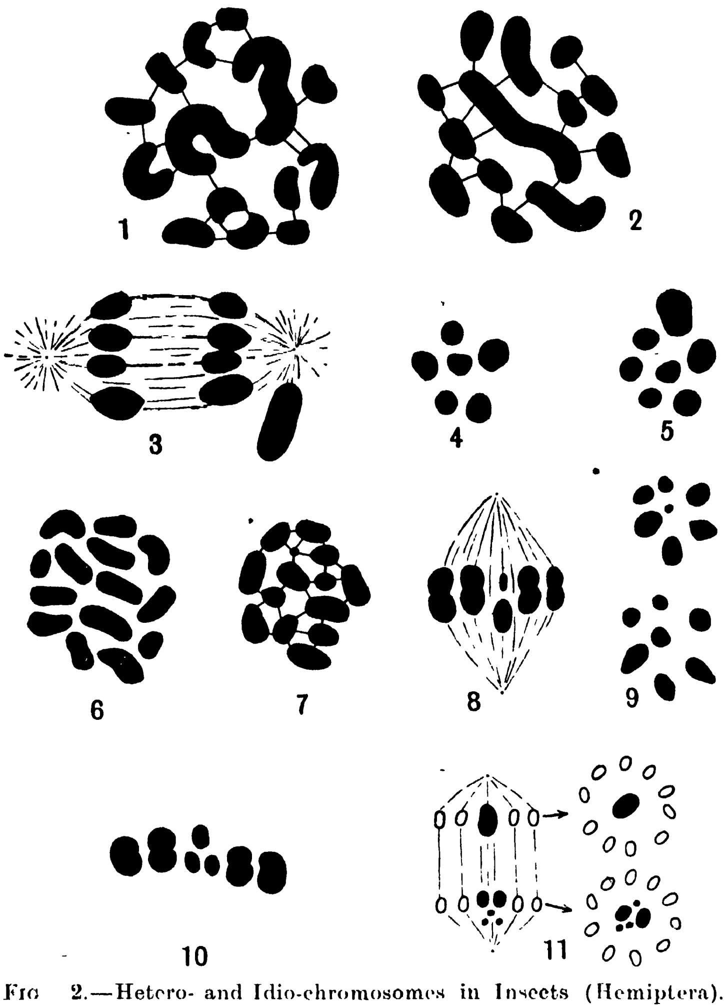


FIG 2.—Hetero- and Idio-chromosomes in Insects (Hemiptera). (Reproduced by permission of the Editor, from *Quart. Journ Micr Science*, LIX (1914), p 499) (1-5) *Protenor belfragei.* (1) Female, equatorial plate before reduction, two large hetero-chromosomes. (2) Similar group of the male, one large hetero-chromosome. (3) Spindle of second maturation-division of spermatozoon; large hetero-chromosome below right pole. (4, 5) Two daughter-plates of same division; hetero-chromosome in group 5. (6-9) *Euschistus variolarius*. (6) Female, equatorial plate before reduction; no conspicuously small chromosome (7) Similar group of the male; one very small idio-chromosome. (8) Spindle of second maturation-division of spermatozoon; large and small idio-chromosomes in centre. (9) Two daughter-plates of same division; small idio-chromosome in upper, large in lower. (10) *Rocconota annulicornis.* Side view of equatorial plate of second maturation-division of spermatozoon, showing large idio-chromosome paired with two small. (11) *Acholla multispinosa*, second maturation-division of spermatozoon, showing large idio-chromosome paired with five small. [(1-10) from Wilson. (11) from Wilson, after Payne].

similar cases, where females transmit while males are affected, have been found in the little vinegar-fly Drosophila, through which we have gained so much of our detailed knowledge of the processes of inheritance--that puny creature, which from its convenient habit of breeding comfortably in bottles, and providing a new and abundant generation every two or three weeks, is immortalized in the history of science.

The wild fly has red eyes; a mutation was found with white eyes—a male. This male, mated to a normal female, produced nothing but normal offspring. Of these, the males never fathered any white-eyed children, but the females, whether mated to their brothers or to other red-eyed males, produced children of whom all the females and half the males, were normal, but the

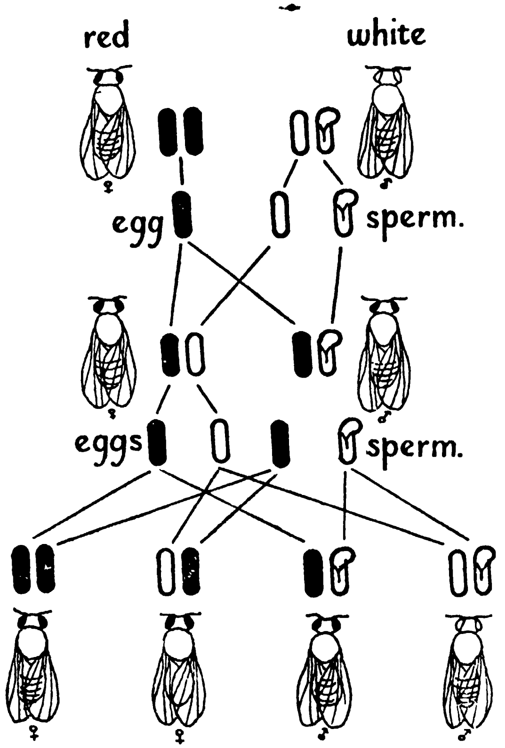


FIG. 3.—Diagram of sex-linked inheritance. Drosophila: red-eyed female by white-eyed male. (After Morgan).

remainder of the males were white-eyed. The scheme of inheritance was identical with that of hæmophilia in man--transmission through females, appearance in males. So far, white eyes had only been met with in males. But on crossing the daughter—herself red-eyed—of a white-eyed father with another white-eyed male, half of *all* the offspring, both female and male, were white-eyed. Finally, if a white-eyed female were mated to a normal red-eyed male, the curious phenomenon of criss-cross inheritance was observed—all the daughters resembled their fathers, all the sons their mothers.

In Drosophila, the female has two X chromosomes, the male an X and a Y. If we suppose that the X chromosomes, besides being concerned in sex, bear the factors for other characters, and that the Y chromosomes do not carry any such factors, then these characters will be inherited exactly like "white-eye" or other sex-linked characters, as the accompanying diagram will show.

Sex-linked characters are found in other animals as well. But where, as in moths, it is the male that possesses two X chromosomes, the female but one, they are inherited in a way the very reverse of that which we have just seen. They are transmitted through males and appear in females; and a precisely similar mode of inheritance is found in birds.

Practical results have already flowed from these facts. As every poultry-breeder knows, it is impossible to tell the sex of an ordinary chicken at hatching. The secondary sexual characters of comb, wattles, spurs, voice, instincts and plumage do not develop until the reproductive organs begin to exert their effect. But when a cross is made into which a sex-linked factor enters, this does not need the secretion of the reproductive organs to express itself as a visible character, and is often obvious at birth. In a cross between a Barred Plymouth Rock hen and a Brown Leghorn cock, for instance, the sex of the chicks can be told at birth by the presence or absence of a white patch in the back of the neck. Crosses between silver and gold birds, made in the right direction, will also give chicks that can be sexed at hatching. If it is desired to do business in day-old chicks, they can thus be all guaranteed female, and the males kept for fattening and eating as young cockerels; and, as a matter of fact, some such procedure is being adopted by various large breeders.

So far there is a strong correspondence between the facts concerning chromosomes observed through the microscope by cytologists and the facts concerning sex-linked characters observed by experimental

breeders in their stocks—a strong presumption that there exists a causal connection between the two sets of facts. Nature, however, has happily provided us with an *experimentum crucis* of her own designing—a tangled and complicated affair, whose unravelling we owe to the distinguished young American worker, Bridges, but which, once unravelled, has finally clinched the matter.

We have just seen that when a white-eyed female Drosophila is mated to a red-eyed male, criss-cross inheritance results, all the daughters being like their father in eye colour, all the sons like their mother. Certain females, however, were found to give abnormal results, producing white-eyed females and red-eyed males, as well as the ordinary two types.*.

Bridges came to the conclusion that this could be explained if the white-eyed females had arisen from an egg in which, through some abnormality, both X-chromosomes had remained in the egg, neither had passed into the polar-body; and the egg had then been fertilised by a Y-bearing sperm. If this were so, two chief results should follow. In the first place, the exceptional females should go on giving exceptions in their offspring; and in the second place, the tissues of the exceptional females, when examined under the microscope, should contain three instead of two sex-chromosomes—two X's and a Y. Both conclusions, together with other minor consequences prophesied by Bridges, were verified, and the proof that X chromosomes are concerned both in the determination of sex and in the carrying of sex-linked factors is now as perfect as that obtained in a good physical experiment.

One interesting further point is to be noted. In the first place, these XXY individuals were perfectly normal females: the presence of the Y, normally only found in males, did not influence them in any way (save by causing hereditary exceptions in their offspring). Further, there have been found males, produced by a similar abnormality of polar-body formation, with one X but no Y. These are normal in appearance, but fail to produce normal sperms, and are sterile. These facts make it clear that the Y-chromosome, in Drosophila, at least, is only necessary as a partner to the X during gamete-formation, but is neither concerned in the determination of maleness, nor with the carrying of hereditary factors. One dose of X or of something in X normally produces a male, two doses a female. We shall see later that the dosage of this "something in X," this *sex-factor*, as we must call it, must be in a definite quantitative proportion to other factors.

In this instance, then, the exception did most definitely prove the rule. It may be mentioned that recent breeding work goes to show that in Drosophila there are certainly over 500 and probably over a thousand sex-linked factors in the X chromosome. It should further be noted that the sex-linked factors are only connected with sex by being lodged in the sex-chromosome. The characters which they concern need have nothing to do with sex, and the sex-linked factors are mostly concerned in the general development of the body in the same way as are most of the factors contained in all the other chromosomes. There are, of course, in most animals, characters in which the two sexes differ—the secondary sexual or sex-limited characters. The factors for these, however, are present in both sexes, as we may see when, for instance, a hen Reeves pheasant is crossed with a male of another species, and, although she herself shows none of the brilliant and distinctive colouring of the Reeves cock, yet transmits it to her male offspring. In other words, sex-linked characters are those whose factors happen to be carried in the sex-chromosome; and the sex-chromosome somehow acts like a switch, turning on not only maleness or femaleness, as the case may be, but also all the secondary characters associated with sex. But to this we shall have to return.

In Drosophila we have certainty as to the causal connection of the X-chromosomes with sex. And this certainty reverberates on to the probability found in other species, and increases it. It is now generally held—and apart from the intrinsic probability of the view, no adequate rival theory is in existence—that wherever sex-linked inheritance is found, there must exist one sex with two X chromosomes, the other with one.*

One interesting consequence of the dependence of sex upon sex-chromosomes, and

* As a matter of fact, Bridges obtained his results chiefly with another sex-linked character, "vermilion eye"; since the principle is identical however, we continue, for the sake of simplicity, to use white eye colour as our example.

* When a Y chromosome is present it appears usually to carry no ordinary factors. A Drosophila without a Y cannot only exist, but is normal in appearance. It is, however, sterile.

one which may have some practical importance, deserves mention here. It will be remembered that in birds and moths it is the female which possesses but one X-chromosome, and forms, therefore, two sorts of eggs, one with an X and one without. It will also be remembered that in female animals, the reduction-division takes place during polar-body formation, so that in any given ovum the X chromosome can either stay in the egg and play a rôle in the embryo, or be thrown out into the polar body, and come to nothing.

Theoretically, then, if we could discover some means whereby, in moths or birds, we could influence the behaviour of the X-chromosome at the reduction division, causing it to remain in or to be cast out more often than usual, we should influence the sex-ratio. Now, this has actually been done in moths. Seiler finds that in a certain species, the proportion of males was markedly increased by exposure to high temperature during the reduction-division, or by causing retention of the eggs in the female's body for an abnormally long time before fertilization, but was markedly decreased by similar exposure to low temperature; and was further able to show that this actually depended upon the movement of the X-chromosome at reduction, high temperature causing it to remain more often in the egg, and vice versa. The proportion of females to 100 males, was only 62 at 35°-37° C., but 155 at 3°-5° C.

The work of Riddle goes to show that similar causes may be at work in pigeons. Here it would appear that the chemical activity of the bird in general is reflected in that of the egg, and that this, in its turn, affects the movement of the X-chromosome at reduction. Active metabolism leads to small eggs; in these, the X-chromosome is usually retained; and a preponderance of males is the result, and vice versa. It cannot be said that the final proof has yet been given for these birds, but after Seiler's work, there exists a very strong probability that we shall be able to find some agency which, in domestic birds, will affect the movement of the X-chromosome, and so alter the sex-ratio to suit our wishes.

It might seem, then, that the sex problem, so far as determination is concerned, was definitely settled. The X-chromosome mechanism is beautifully designed to give in each generation males and females in equal proportions; it certainly operates in some animals; it must, said some biologists, be the rigid rule for all.

But many points remained unexplained. In the first place, the explanation was not complete. It left us with the chromosome sex-difference on the one hand, the adult sex-difference on the other, but no notion of how the former difference was translated into the latter during the processes of development. It was not a physiological explanation. In the second place, the ratio of the sexes is by no means always equal; in some animals, including man, there are born more males than females, in others the reverse is the case. Sometimes the sex-ratio at one season is different from that of another; possibly it may differ in some species according to the age of the mother. How are we to account for all these facts on the sex-chromosome theory? Finally, how are we to account for the various types of sexual abnormality, up till recent times all lumped together under the general term of hermaphroditism, which occur in man and many animals?

A study of these abnormalities will, as a matter of fact, be our best approach to a further analysis of the problem. It has long been known that in some animals, notably in insects, strange sex-monsters

(1).

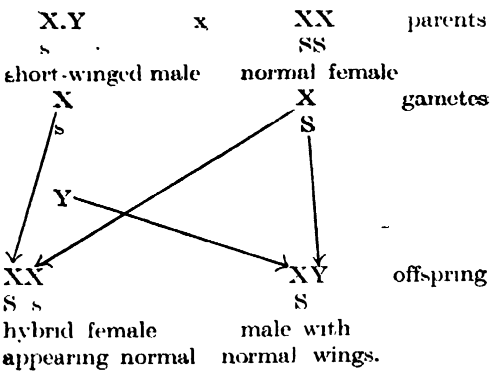
(2).

FIG. 4.—(1) Pine moth, *Bupalus piniarius*, female on the left, male on the right side. (2) Gynandromorph Ant (*Myrmica scrabinodis*), characters of the male on the left, those of the worker on the right.

known as gynandromorphs from time to time occur, in which the creature is a mosaic of male and female characters. Very often they are bilateral—i.e., one half of the body is entirely male, the other half entirely female. Very remarkable appearances may thus be produced. In ants, for example, and some wasps, one side may be male and therefore winged, the other worker-female and therefore wingless.

When good fortune has brought up a gynandromorph among a brood of insects which are heterozygous for a sex-linked character, it is found that this too may be different on the two sides of the body.

For instance, a factor which produces short wings in Drosophila is lodged in the sex-chromosome. If a short-winged male be crossed with a normal female, inheritance will be according to the following diagram; (we use s as the symbol for the factor which produces short wings, S for the similar factor producing normal wings. s is recessive, so that an individual with constitution Ss *appears* normal).



When bilateral gynandromorphs appear in such a brood, they are sometimes normal-winged on both sides, sometimes normal-winged on the female side, short-winged on the male side. If the animal is also hybrid for non-sex-linked characters, these, however, are *never* different on the male and female sides.

From a multitude of similar facts, it can be concluded definitely that in Drosophila the cause of gynandromorphism is a lagging of one of the X-chromosomes after one of the early cell-divisions of a female embryo, and its consequent failure to become incorporated in the resulting nucleus. This nucleus will only possess one instead of two X chromosomes, and all its descendants will show male characters. Bilateral gynandromorphs can only be produced if the abnormality occurs at the first division of the fertilized egg; if it occurs at the second division, one quarter of the body will be male; and so forth. Gynandromorphs in Drosophila are therefore all originally females in which certain definite areas of the body, through an abnormality of chromosome behaviour, have become male. They are spatial mosaics as regards sex.

In other insects, as for instance bees, gynandromorphs may occur. Here again it is quite clear that the female parts have two X chromosomes, the male parts one, and that an abnormality of division is at the bottom of the matter—although the precise type of abnormality is probably different.

Gynandromorphs thus constitute another and important piece of evidence for the sex-chromosome theory. They do not, however, throw further light on the chromosomes' mode of action. For this we must turn to another type of abnormality, the so-called hermaphrodites obtained by crossing certain races of moths. In this field, remarkable results have been obtained by the German biologist Richard Goldschmidt. His laborious researches, carried out over a series of years and developed as time went on with great analytic power, have given us a new concept that of developmental intersexuality, as opposed to hermaphroditism or gynandromorphism. They are further a striking example of the value of genuine scientific method in eliciting the real meaning of well-known facts. It had long been known to entomologists that crosses between closely related species of moths, and more particularly between the European and Japanese species of that notorious forest pest the Gipsy Moth (*Lymantria dispar* and *L. japonica*) gave a considerable proportion of animals which were intermediate between male and female. This it was which first attracted Goldschmidt to the problem.

As a result of his breeding work, he found that the different races of *Lymantria* could be arranged in two series, which he calls *weak* and *strong*. If a "weak" male is crossed with a "strong" female, the offspring are normal. But if the cross is made in the opposite sense, then, while 50% of the offspring are normal males, the other 50% are more or less intermediate between males and females. These we call intersexes, and, as we shall see later, they are

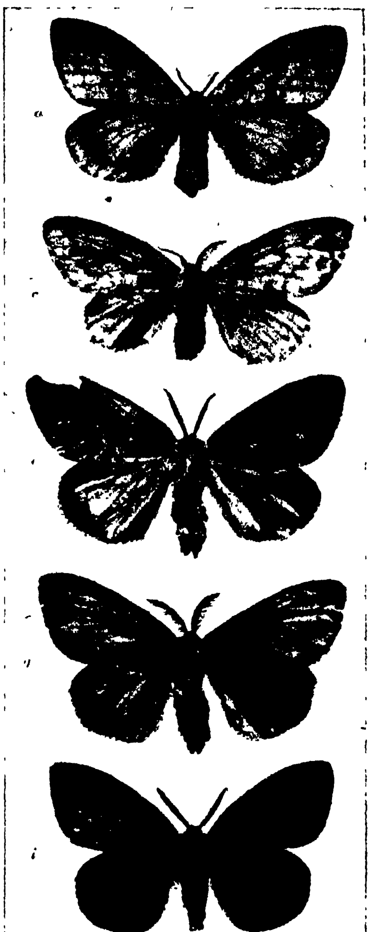


FIG 5.—*Lymantria*: female intersexes. Top, slight degree of maleness. Bottom, almost complete transformation to male (After Goldschmidt).

really females modified in the direction of maleness. Further, he found that the races within each group differed among themselves. Some "strong" races were very strong; the intermediate forms produced when these were used as parents were much more male than the offspring of other less strong races; and similarly the same "strong" race crossed with one "weak" race would give abnormal forms which were scarcely to be distinguished from ordinary females, while when crossed with another, it would give a strongly male type of intersex. The second weak race would thus be called "weaker" than the first.

On the basis of his results he was soon able to prophesy, and to prophesy correctly. If strong race A with weak race P had proved to give moderate intersexuality, while with race Q it gave strong intersexuality; and if further, another strong race B had given moderate intersexuality when crossed with Q, then it could be safely prophesied that this second strong race should give only a slight degree of intersexuality when crossed with race P, and so forth (see table).

It was further found that the racial character of "weakness" was always transmitted in the female line alone, possibly through the agency of the cytoplasm of the egg. But the character "strength" behaved like any other Mendelian character, or, rather, I should say like any other Mendelian sex-linked character. It behaved, that is to say, as if it were in the sex-chromosome, or as if it *were* the sex-chromosome. From analogy with other cases, there can be no reasonable doubt that this character for "strength" is actually what we usually call the sex-character itself—the something in the sex-chromosomes which is connected with the determination of sex.

But, as we shall see more in detail later, the determination of sex is an affair of balance between the sex-factor properly so-called, and other factors. The same is obviously true here. A change in the sex-factor itself will affect the degree of intersexuality after a cross, but so also will a change in the factor concerned in "weakness."

Races.		Degrees of Intersexuality.				
Strong.	Weak.	Very marked.	marked.	moderate.	slight.	Very slight.
A	P	A × R	A × Q	A × P	B × P	C × P
B	Q		B × P	B × Q	C × Q	
C	R			C × R		

It is of considerable interest from a general evolutionary standpoint to find that "strength" and "weakness" are bound up with geographical distribution and with the requirements of the life-cycle. Most Japanese races, for instance, are "strong." The most northerly, however, are "weak;" they inhabit a region whose annual temperature-curve is similar to that of Central Europe, and have a rate of growth similar to that of the "weak" European races.

This in its turn is connected with the most curious fact about the abnormal individuals; they are not intermediate like a gynandromorph, one half male and the other half female. They are not sex-mosaics in space, *but in time.* They start their development as normal females; at a particular moment they come to a critical point, change their mode of life, and finish their career as males. Since the hard parts of an insect are external, and composed of the dead material chitin, any of them which are laid down before the change remain unaltered after it, so that by an inspection of the parts which are normally different in the two sexes, it is possible to say of any particular intersex just when during its life-history it came to the moment which switched it over from one sex to the other.

It is clear that if the change were to operate very early, before any of the hard parts were formed, then we should get an animal which, although it possessed the chromosome-constitution of the female, and had actually started to develop along the paths which lead to the condition which we call femaleness, yet was indistinguishable by any ordinary test, whether of appearance or behaviour, from a normal male. And as a matter of fact, in certain crosses the offspring, instead of consisting of 50% males and 50% intersexes, consist entirely of males. 50% of these are normal males, but obviously the remainder are transformed females, and instead of having the normal chromosome constitution of males, which in moths is XX, will possess that of females—XY. This being so, such transformed males, on being bred from, will not give the normal sex-ratio at all—but that is another story, to which we must return later.

The first and most startling thing to realise is that an individual predetermined, as it were, for one sex may be transformed into an individual of the other sex, and may beget offspring normally in its transformed condition.

Besides female intersexes, which ought to be, and start as, females, Goldschmidt has also found male intersexes. The conditions for their genesis (since the male moth is XX in constitution) are more complicated, and they usually only appear in the second generation after an inter-racial cross. As would be expected, the male intersexes do not resemble the female intersexes, except in the one particular of combining male and female characters in their single persons. But in them the male characters are to be seen in early-developed parts, the female characters in those which are formed later, after the predestined turning-point.

We inevitably ask ourselves what is this strange mechanism which permits the animal to develop normally up to a certain stage, and then forcibly swings it over into the alien paths proper to the development of the opposite sex. The answer is apparently to be found in some simple difference in rate of chemical reaction between the sex-factors of the "strong" and the "weak" races.

We are by now for the first time in a position to be able to go back to first principles in our subject, and to realise something of the *raison d'être* of the sex-chromosome mechanism.

In the first place, as we have seen, the arrangement by which one sex contains the sex-factor in single dose and is heterozygous for it, as the Mendelians say, while the other sex contains it in double dose and is homozygous for it, is the simplest way of ensuring a I:I ratio of the two types.

What really occurs when an egg with one chromosome-constitution turns into a male, one with another constitution into a female? There are plants, such as *Polygonum amphibium* and the water ranunculus, which will develop into ordinary-looking land plants when growing in a dry environment, but assume a typically aquatic appearance, with floating leaves and hollow stem, when growing in water. The determining factor is here the external environment. In all higher animals, however, it is the internal environment which is of chief importance, the animal's metabolism, the chemical processes of its life, the composition of its body fluids, and so forth. The difference in chromosome constitution between the two sexes seems to bring about a difference in the internal environment of the developing embryo,

one type of internal environment allowing male characters to develop, the other favouring the appearance of female characters. Now it appears that there are two definite substances which directly or indirectly are responsible for the development of one or other of the two types of internal environment. We may have one which we may call, in a shorthand way, the female-determining substance, because it is responsible for producing the female-determining environment, the soil which encourages the growth of female and suppresses that of male characters; and the other in similar fashion we may call the male-determining substance.

These two substances in their turn are produced, apparently directly, by the sex-factors in the hereditary constitution. In moths, it is the factor for maleness, for producing the male-determining substance. which is present in the X-chromosomes. It is, therefore, present in double quantity in the male, in single quantity in the female, The female-determining substance, on the other hand, is produced by the female sex-factor, which exists in the same dosage in all eggs. If we call the male-determining factor M and the female-determining F, then we have a quantitative relation between the two such that 2M is greater than F, while F is greater than 1M.

But this is not all. These sex-factors are in some way giving rise to the sex-determining substances. Perhaps, as Goldschmidt suggests, they are actually enzymes, ferments. Be that as it may, it is clear that the rate at which the sex-determining substances are produced must continue to bear a pretty constant relation to the quantities of the sex-factors present in the constitution, if the two types of internal environment are to be produced correctly. But now suppose that we found a race of moths whose sex-factors had the property of working faster than normal, of producing more sex-determining substance in a given time than do the sex-factors of other races. What will happen if a male of the faster-working race is crossed with a normal female? The female sex-factor is always inherited through the mother. All the offspring, therefore, will have female-determining substance produced in them at normal rate. The male will possess one normal and one quick-working male-determining sex-factor; they will thus produce more male-determining substance than usual in relation to the amount of female-determining substance.

The females, on the other hand, will contain only one male-determining factor, and that will come from their fathers, and therefore be quicker-working than usual. As a consequence, the amount of male-determining substance produced will gradually increase relatively to the amount of female-determining substance, and finally catch up with and surpass it. When it does this, it automatically switches on, so to speak, the male-determining environment, making it impossible from now on for any but male characters to develop. The animal, in fact, is a female intersex, and the case we have been considering is that of a cross between a "strong" male and a "weak" female. So-called strength and weakness are only signs of greater or less rapidity in the production of male-determining and female-determining substances.

An identical result would have been obtained if the male had been less "strong" but the female parent much "weaker" than normal. It is not the absolute, but the relative rates of production of male and female-determining substances that count in the formation of intersexes. A diagram will make this clear. A *plus* sign signifies a "strong," a *minus* sign a "weak" sex-factor.

European female × Jap male.

M^-F^- × $M^+M^+F^+$

M^+F^- (intersexual female.) $M^+M^-F^-$

To give male intersexes, it is necessary to combine a strong "female" factor with two weak "male" factors, and this will only occur in the second generation after a cross, as under.

Jap female × European male.

M^+F^+ × $M^-M^-F^-$

M^-F^+ × $M^+M^-F^+$

M^-F^+ M^+F^+ $M^+M^-F^+$ $M^-M^-F^+$ (intersexual male.)

Inexorably the sex-factors in normal development build in a series of stages, each stage conditioned by the one before, conditioning the one that comes after, and culminating in the blossoming of the characters associated with one sex or the other. As inexorably, when unequal sex-factors are mated together in an embryo, the one overtakes the other in the amount of substance which it can produce in a given time; and so two mechanisms, each of which by itself is designed to give normal-sexed individuals in normal proportions, give rise when combined to this relentless change of sex, rendering useless all the earlier part of the development, and producing (save in cases of complete sex-reversal) organisms which fall between two stools into biological uselessness.

It is worth noting the possibility which I frankly confess appears a doubtful one - that in animals of domestic importance to man we may be able to find races, geographical or otherwise, which when crossed would produce transformation of one sex. In mammals, if this were possible, the easier transformation would be the more desirable--from male into female.

This idea of the two internal environments, themselves determining one or other set of sexual characters, determined by the relative amounts and rates of working of the sex-factors in the constitution, will throw considerable light on to the conditions to be found in vertebrates.

In this highest group, affairs are more complicated; there appears to be another link in the chain. The internal environment determines the formation of a male or female reproductive organ, and this in its turn determines the appearance of all the other sexual characters by means of some internal secretion or *hormone* which it produces.

In insects, this does not occur. Castration, whether in male or female, whether in early or late stages, and whether followed or not by the transplantation of the reproductive organs of the opposite sex, is without effect upon the sexual characters of the body as a whole. It has been known for a very long time that this is not so in vertebrates, for castration has been practised on man and animals since time immemorial, and its effects must always have attracted notice. But it is only in the last few years that our knowledge has been put upon a broad and accurate basis. The merit of the work of Steinach, Sand, Moore, and Lipschütz has been that, starting from a theoretical premiss, they have confirmed it by careful experiment. The premiss was the idea, first clearly enunciated by Ancel and Bouin, that the interstitial substance of the vertebrate reproductive organ produces a secretion or hormone which controls the development of all the other sexual characteristics of the body. Steinach took very young guinea-pigs, removed their reproductive organs, and then into some of them grafted reproductive organs taken from animals of the opposite sex. Those which were only castrated remained in many respects unchanged, in others assumed a neutral, intermediate aspect. Those, however, which in addition received into their circulation the secretion of the grafted reproductive organ of opposite sex became in most respects as if they were in reality of this opposite sex. Females became male in appearance and in instincts, males became female. Castrated males with grafted ovaries not only were attractive to normal males, but secreted milk and suckled young, exhibiting normal maternal behaviour, although, of course, they were incapable of actually producing offspring.

FIG. 6—Feminized male guinea-pig (testes removed, ovaries grafted in) suckling young. (After Steinach).

These experiments made it clear that the reproductive organs do actually secrete hormones which are specifically different in the two sexes; that the different sexual instincts of male and female depend upon the activating of different tracts in the brain, whose total potentialities are the same in both sexes; and that very considerable changes in bodily structure and rate of growth are due to the action of these substances even after birth.

The earliest stages of sexual differentiation, however, are pre-natal; and the work

we have been chronicling throws no light upon them. Fortunately, Nature herself is in the habit of performing an experiment of this nature, and the acuteness of Lillie enabled us to interpret it. It has been long known to stock-breeders that when twins are born in cattle, one of the pair is often abnormal in its sexual characters. These sexually abnormal individuals are known as free-martins. Various lines of evidence conspire to show that the free-martin is an abnormal female, and that it only occurs as one of a pair of twins, and only when the other member of the pair is a male. Lillie was able to demonstrate that when twins are produced in ruminants, the membranes of the two embryos coalesce into one. But whereas in sheep and goats, with rare exceptions, the coalescence is confined to the membranes, in cattle it always goes further and extends to the blood-system. From this it results that, in cattle, whatever substances are present in the blood of one embryo will be present in that of the other also. It appears that the reproductive organ of the male embryo starts to produce its characteristic hormone before that of the female; or possibly that it produces a more potent hormone. In any event, it is the presence of the male hormone circulating through the female embryo that influences its development, produces the strange intermediate condition seen in the free-martin, in which the internal organs are predominantly male, the external parts predominantly female, while the secondary sex-characters are intermediate.

If there were any doubt as to the correctness of Lillie's views, this has been dissipated by the remarkable experimental results obtained by Minoura in Lillie's laboratory. Minoura has been able to produce artificial free-martins, of both sexes, in chicks.

Removing a part of the shell of eggs in the second week of incubation, he grafted on to the vascular area of the embryonic membrane a small portion of reproductive organ, male or female, taken from another bird. When the reproductive organ was of the same sex as the embryo on to which it was grafted, no abnormality was to be seen, but when it was of opposite sex, far-reaching alterations were produced in the short period—6 to 12 days—that elapsed before the chicks were examined. Before hatching, of course, none of the secondary sexual characters—comb, spurs, plumage, instincts—are developed. *Per contra*, it is the reproductive organs themselves, together with their ducts and accessory glands, which are being differentiated from the original indifferent state.

All intermediate stages, both from maleness towards femaleness and *vice versa*, were found in the operated chicks. After this result, it can definitely be stated that vertebrate embryos, whether male or female by chromosome constitution, pass through a more or less indifferent or neutral condition of their reproductive system, and that the conversion of this into the condition characterising one or the other sex is only possible as the result of the presence of the sex-hormone appropriate to that sex. Excess of sex-hormone of the opposite sex will divert the developing animal from its proper sex to an intermediate or reversed condition.

Two interesting points arise out of these results. Firstly, what is the reason that a male mammalian embryo is not influenced in its development by the female hormones derived from its mother's reproductive organs, and circulating in her blood? We can only say that there must be some unknown agency which prevents this, or else all male mammals would be sex-intermediates; and that another problem is here presented for solution to those who are interested in the interaction of mother and fœtus.

The second, and more general point, is this: We see that the first sign of differentiation in the developing vertebrate reproductive organ is the production of a substance which, one may properly say, encourages itself. The female reproductive organs which Minoura used as grafts, were taken from fowls of all ages, from 10-day chicks to mature hens; the effect of all was the same—to help convert the indifferent type into the female type of reproductive organ. The same, *mutatis mutandis*, was true of the male organs used. I want to draw attention to the possibility that these specific substances produced by the reproductive organs are identical with specific substances present in the factorial complex that makes up the hereditary constitution. From Guyer's recent work we know that if the lens of a rabbit's eye is ground up and injected into fowls, and the fowl's blood with the resultant antibody is injected into pregnant rabbits, the young may show defects of their lenses, and that these defects may be inherited

through both sexes. This indicates that the substance of which the lens is composed is, in some particular, identical with the substance which determines its formation in development, and is transmitted in heredity. The specificity of the male and female sex-hormones in birds from the earliest to the latest stages of sex-differentiation, indicates a similar possibility for them. If so, unlimited fields are opened up for the joint efforts of genetics and immunology. I mention the possibility, since it is of the greatest importance that it should be tested, and since both geneticists and those interested in serum-therapy and immunity should bear it in mind.

It remains to mention one further experiment in this field. Some workers have interpreted these results to mean that there is a definite antagonism between the sex-hormones. Moore, however, has succeeded in grafting an ovary into a young rat from which one testis had been removed, and found that both male and female gametes grew to maturity in a normal way. It is, therefore, possible to balance the male and female hormones in one and the same individual, and so to produce an artificial hermaphrodite. The apparent antagonism seen in the natural and artificial free-martins, must be due to the fact that the reproductive system before birth or hatching is indifferent as regards its structure, and is in what the botanist call its sensitive stage, during which it may react to abnormal environment by alterations of structure, but after which it is no longer capable of so reacting. We saw a similar phenomenon in the case of the hard parts of the intersexual gypsy moths (*Lymantria*).

(*To be continued.*)

OBITUARY.

EDWARD HOPKINSON, M.A., D.Sc., M.P.—Mr. Edward Hopkinson died at his residence, Ferns, Alderley Edge, on the 15th inst. Born in 1859, he was educated at Owens College, Manchester, and Emmanuel College, Cambridge, where he obtained a foundation scholarship. He graduated as tenth Wrangler in 1881, and two years later was elected a Fellow of his college. In 1882 he became assistant to Sir William Siemens. He carried out experiments at Portrush on the first electrical tramway in the United Kingdom, and in 1883, in conjunction with Mr. Alexander Siemens, he read a paper on the subject before the Royal Society of Arts, for which he was awarded a silver medal. In the same year he also received from the Institution of Civil Engineers a gold medal and the Telford Premium for a paper on the construction and working of the Bessbrook and Newry Tramway, which is worked by water-power.

He joined the firm of Messrs. Mather and Platt, of Salford, in 1884; he became a partner in 1887, and in 1899, and when the firm was enlarged by the merging into it of Messrs. Dowson, Taylor & Co., he was appointed vice-chairman. He was also vice-chairman of the Chloride Electric Storage Battery Company.

Mr. Hopkinson was associated with some of the largest developments in electrical traction. He received from the Institution of Civil Engineers the Telford and George Stephenson Premiums and Medals for his paper on the City and South London Railway; his firm were responsible for the original electrical equipment of the Douglas and Laxey Electric Tramway and the Snaefell Mountain Railway, and for the electric tramway between Blackpool and Fleetwood.

He was a past president of the Institution of Mechanical Engineers, a member of the Council of the Institution of Electrical Engineers, and vice-president of the Manchester Steam Users' Association. He also did much good work in connexion with the Salford Royal Hospital, and he was chairman of the Associates of Owens College, and a member of the Court of Governors. He served on the Indian Industrial Commission (1916-18), and on the Industrial Fatigue Research Board of the Department of Scientific and Industrial Research. He entered the House of Commons in 1918 as Unionist Member for the Clayton Division of Manchester.

FRUIT CULTIVATION IN CZECHO-SLOVAKIA.

Czecho-Slovakia has a climate particularly favourable for fruit growing except in the high mountainous regions, and apple cultivation was a flourishing business as early as the eleventh century. In spite of the successive wars which swept over Bohemia and Moravia, fruit raisers went on selecting and improving their stocks, protected by royal patrons and later by State laws.

According to a report by the United States Assistant Trade Commissioner at Prague, Czech nurserymen have succeeded in producing several varieties of fruit which have a good reputation in the near-by countries, particularly Germany. Among these are the "Borsdorf apple," the "virgin apple," the "raspberry apple" of Holovousy, the Solany pear, and the Colomas. The so-called "red apple of Stettin" (known in Bohemia as the "vejlimek") is of Czech origin, the seeds having been carried to Stettin by Czech emigrants who were driven out

of their country after the battle of the White Mountain.

Most of the orchards are in Bohemia and Moravia, and fruit culture was made more profitable there by the existence of so many species, giving good opportunities for grafting and production of new varieties Many nurseries were occupied with this sort of work, the principal ones being those of J Vesely at Molitorov, Mazanek at Soudna, Masek at Turnov (all in Bohemia), and Felbinger at Zilosice in Moravia During the war these and other nurseries suffered somewhat, principally through not being able to get the wild stocks and grafts formerly imported from Germany, Holland, and France.

More than half the fruit orchards of Czecho-Slovakia are in Bohemia, or about 30,000,000 fruit trees The districts which are richest in fruits are the regions in the vicinity of the Elbe, especially near Melnik, Litomerice (Leitmevitz), Jicin (Gitschin), and Kadan. Moravia has about 10,000,000 trees Having, on the whole, a southern exposure and a warmer climate, the Moravian groves consist partly of trees which need a milder growing season, such as apricot trees The richest sections of Moravia are the slopes of the Carpathians, where plums and apples are grown in connection with some of the stock farms, a profitable combination for the farmers. In Silesia there are 2,000,000 trees, but the exposure of this part of the State is northern and the winters are harsh and the springs late. In Slovakia there are about 10,000,000 fruit trees and in Carpathian Russia about 3,000,000. These districts, covering an area of about 23,910 square miles, have a climate which is favourable for fruit growing except in the alpine districts However, the culture of fruit is much more primitive than in the western parts of the State.

In Slovakia there are still traces of the so-called "community orchards" which were established under the old Hungarian law The idea of the "community orchard" was a good one, but in practice these orchards steadily deteriorated because they were placed in charge of Government officials appointed from Budapest, who secured their positions through influence and were apt to know nothing whatever about fruit growing.

There are said to be about 55,000,000 fruit trees in Czecho-Slovakia, of which four-fifths are bearing. Two-thirds of these are stone-fruit trees, and among them the "quetsch" plums are estimated to constitute about half of all the fruit in the country. These plums are found in great quantities in Bohemia, the ordinary plums growing in Slovakia (especially in Trencin) and Carpathian Russia, and both kinds in Moravia.

Pear and apple orchards are plentiful throughout Bohemia and Moravia— chiefly in the sheltered regions near Litomerice (Leitmeritz)--and in the Slovakian counties of Trencin (Trentschen), Tekov (Bars), and Hont.

Cherry orchards are found in all parts of the country, predominating in Moravia near Ivancice (Eibenschitz), Znaim (Znojmo), Kyjov (Gaya, Gaja), and Hodonin (Goeding), and in Slovakia at Bratislava (Pressburg), Hont, Nitra, Krupina, Sabina, and Nove Mesto and Vahom (on-the-Vaag).

Apricots are found in Moravia near Zidlochovice, Hodonin and Straznice; and in Slovakia near Bratislava and Ostrihom (Estergom). Currants are grown in Moravia in the vicinity of Brno (Brunn), at Bosonoby and Jundrov, where there are also ancient vineyards, and at Devin near Bratislava Peaches are not grown in considerable quantities anywhere

It has been officially estimated that the total fruit harvest in Czecho-Slovakia in 1918 was almost 1,100,000 metric tons, of which 650,000 tons were grown in Bohemia and 93,000 tons in Moravia. Figures are not obtainable for Slovakia. Of this amount not all can be consumed by the home market, of course, and a large part is exported, while another large share is made into preserves Before the war apples were the principal export, then "quetsch" plums, then pears (especially summer pears), then cherries. Exportation of fruit was chiefly to Germany, Russia, and Vienna. There is active trading in fruits in the regions of Litomerice and Lovosice (Lobositz), where ten per cent of the fruit orchards of Bohemia are found; in the districts around Louny (Laun) and Zatec (Saaz); and in those of Melnik and Prague which contain 9 per cent of the trees cultivated in Bohemia.

The preserving and canning of fruit was one of the few trades which the war enormously helped, as fruit was sent in large quantities to soldiers in the field and became one of the war staples There are now about 400 factories producing all kinds of canned fruits in Czecho-Slovakia, particularly jams In 1919 as many as 1,500 carloads of jams were made, for which 7,500 metric tons of sugar were used.

Fruit canning and preserving is also an important affair in every peasant household. The "quetsch" plums are especially prized, being either made into marmalade or dried on the drying stoves which one sees in many villages. The distilled juice of the "quetsch" and other plums is a highly prized drink in Moravia, and especially in Slovakia and Carpathian Russia. In times past the making of brandy was the only use made of plums in Slovakia and Carpathian Russia According to Hungarian statistics, there existed in 1904—5 some 69,000 brandy distilleries in Hungary, of which 62,000 belonged to peasants and the rest to large industries. In that year home stills produced 200,000 hectolitres (4,400,000 Imperial gallons) of brandy, and the industrial stills 520,000 hectolitres (11,440,000 gallons) of brandy wth a fifty per cent. alcoholic content. Of this total, about one-sixth, or 120,000 hectolitres (2,640,000 gallons), were made in Slovakia and Carpathian Russia. The greater part of this brandy was

consumed at home. In order to discourage the tendency of peasants to consume too much, the new laws forbid the making of plum brandy except by communities and agricultural co-operative societies.

MENTHOL PRODUCTION IN JAPAN

Menthol crystal is a Japanese product the use of which is constantly increasing. It is a residue from the refining of the oil distilled from a variety of peppermint grown in Okayama and Hiroshima Prefectures, in Yamagata, and in the northern island of Hokkaido According to a report by the United States Commercial Attaché at Tokio, the greater part of the product comes from Hokkaido, where the mint crop is a favourite one for farmers owing to the distilling work it furnishes during the long and otherwise unprofitable winters Plants of this region, however, are less rich in peppermint oil than those grown in Okayama and vicinity The crystal finds its chief market in America, whereas the peppermint oil is sold mostly to England; before the war it went to Germany.

According to official figures issued by the Department of Agriculture and Commerce, the production of Menthol Crystal and peppermint oil in Japan during 1918 and the previous four years was as follows:—

Year.	Menthol crystal		Peppermint oil.	
	Pounds	Value	Pounds	Value.
		£		£
1918	440,290	284,000	520,533	75,000
1917	566,328	279,000	569,475	73,000
1916	471,550	233,000	541,081	72,000
1915	501,581	197,000	575,815	80,000
1914	320,164	160,000	326,665	61,000

Official figures have not been published for later years, but it is understood in the trade that the 1919 production was about 330,000 pounds for crystal, and the 1920 production 265,000 pounds of crystals and an equal amount of oil.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, JANUARY 30 Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Mr J. Mackintosh, "Milk Recording Societies and their Effect upon the Dairying Industry."

Mechanical Engineers, Institution of (Yorkshire Branch), Y.M C.A., Albion Place, Leeds, 7.30 p.m. Chairman's address.

Architectural Association, 34, Bedford Square, W.C., 7 30 p.m. Mr H. B. Creswell, "Ourselves."

TUESDAY, JANUARY 31..Illuminating Engineering Society and Royal Aeronautical Society (Joint Meeting) at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C.. 8 p.m. Lt.-Col. L. F. Blandy. "The Use of Light as an Aid to Aerial Navigation."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. H. H. French, "Our Old Village Churches and their Story."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. H. H. Turner, "Variable Stars." (Lecture I.)

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Col. T. C. Hodson, "The Primitive Culture of India." (Lecture II.)

WEDNESDAY, FEBRUARY 1..University of London, University College, Gower Street, W.C., 5 p.m Mr. H. G. Spearing, "The Development of Art in Crete and in Greece." (Lecture I.) 5 p.m. Sir Frederick Bridge, "Sir W. Leighton's Great Collection of Early 17th Century Mototo by Eminent British Composers." (Lecture III)

United Service Institution, Whitehall, S W., 3 p m. Rev. H. W. Blackburne, "Existing Organisation and Work of the Royal Army Chaplains' Department."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. R. S. Griffith, "The Virulence of Tuberculosis Bacilli and the Circumstances under which it may vary."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p m. Mr. H. T. Smith, "The Curse of Work."

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p m. Annual General Meeting. (1) Messrs. J L Lizius, and N Evers, "Studies in the Titration of Acids and Bases." (2) Dr J C. Drummond, and Mr. A. F. Watson, "The Sulphuric Acid Reaction for Liver Oils and its Significance." (3) Messrs W Dickson, and W C. Easterbrook, "The Quantitative Separation of Nitrobody Mixtures from Nitro-glycerine"

Geological Society, Burlington House, W., 5 30 p m.

Electrical Engineers, Institution of (Wireless Section), Savoy Place, Victoria Embankment, W C, 6 p m. Major J Erskin-Murray (a) "The Determination of the Decrement of a Distant Sending Station" and (b) "Some New Methods of Radio-Navigation"

(South Midland Centre). The University, Birmingham, 7 p m. Dr. S. P Smith, "Single and Three-Phase Commutation Motors with Shunt and Series Characteristics."

THURSDAY, FEBRUARY 2..Royal Institution, Albemarle Street, W. 3 p m Sir Napier Shaw, "Droughts and Floods" (Lecture I)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W C, 6 p.m. Messrs L. J. Romero and J. B. Palmer, "The Interconnections of A.C. Power Stations."

FRIDAY, FEBRUARY 3..Midwives Institute, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C, 7 p.m

Royal Institution, Albemarle Street, W, 9 p m Sir Francis Younghusband, "The Mount Everest Expedition."

Philological Society, University College, Gower Street. W.C, 8 p.m. Prof. Sir Israel Gollancz, Presidential Address.

Engineers, Junior Institution of, Caxton Hall, Westminster, S W., 8 p m. Major W. Gregson, "Utilization of Waste Heat from Internal Combustion Engines."

Chemical Industry, Society of (Manchester Section), at the Textile Institute, 16, S. Mary's Parsonage, Manchester, 7 p.m. Drs. T. Callan and J. A. R. Henderson, (1) "The Estimation of the Nitro Group in Aromatic Organic Compounds." Part 2., and (2) "The Use of Potassium Bromate in Volumetric Organic Analysis."

SATURDAY, FEBRUARY 4..Chromatics, International College of, Caxton Hall, Westminster, S.W., 3 15 p.m. Rev. J. J. Pool, "Peacocks: The Splendour of their Plumage and the Effulgence of their Colouring."

Municipal and County Engineers, North Eastern Meeting and Wakefield.

Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. de Sellincourt, "Humorists of the Seventeenth Century." (Lecture I.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 187

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 6th, at 8 p.m. (Cantor Lecture). C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." (Lecture III.)

TUESDAY, FEBRUARY 7th, at 4.30 p.m. (Dominions and Colonies Section.) WILLIAM TURNBULL, Timber Commissioner for the Government of British Columbia, "The Timbers of British Columbia." LORD CLINTON, Forestry Commissioner, in the chair.

WEDNESDAY, FEBRUARY 8th, at 8 p.m. (Ordinary Meeting.) EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry," SIR ARTHUR DUCKHAM, K.C.B., M.Inst.C.E., in the chair.

CANTOR LECTURE.

On Monday evening, January 30th, Mr. C. Ainsworth Mitchell, M.A., F.I.C., delivered the second lecture of his course on "Inks."

The lectures will be published in the *Journal* during the summer recess.

NINTH ORDINARY MEETING.

WEDNESDAY, JANUARY 25th, 1922: MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Beadle, Ormond Alec., Oxford.
Chettiar, Rao Sahib P.K.A.C.T. Veerappa, M.B.E., Kottaiyur, Madras, India.
Oppenheimer, Maurice, Rangoon, Burma.
Taylor, Samuel Daniel, Oxford.

The following candidates were balloted for and duly elected Fellows of the Society:

Chari, N. S. T., M.A., Calcutta, India.
Gibson, Miss Marion Campbell, Perth, West Australia.
Gwyn-Williams, Captain R. H., O.B.E., M.C., Balaghat, Central Provinces, India.
Hardcastle, Charles Henry, Bombay, India.
Harding, Henry George Alan, F.C.S., North Sydney, N.S.W., Australia.
Lahiri, Purna Chandra, L.M.S., Dibrugarh, Assam, India.
Saksena, Ram Babu, M.A., LL.B., Saharanpore, United Provinces, India.
Stubbs, Roy Wilson, Karachi, India.
Sturrock, George S., Lahore, Punjab, India.
Watson, Edwin Alexander, Calcutta, India.

A paper on "Photosculpture," was read by Mr. Howard Maurice Edmunds.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

FRIDAY, JANUARY 27th; SIR WILLIAM S. MEYER, G.C.I.E., K.C.S.I., High Commissioner for India, in the chair.

A paper on "The Timbers of India and Burma," by Mr. Alexander L. Howard, was read by Mr. A. Arnold Hannay.

The paper and discussion will be published in a subsequent number of the *Journal.*

CASES FOR JOURNALS.

Cases for keeping the current numbers of the *Journal* are now obtainable. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s.* 6*d.* each, on application to the Secretary.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s.* each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING

WEDNESDAY, JANUARY 18th, 1922.

PETER CHALMERS MITCHELL, C.B.E., M.A., D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, in the chair.

SOME RECENT ADVANCES IN THE BIOLOGICAL THEORY OF SEX.

By JULIAN S. HUXLEY, M.A.,
Fellow of New College, Oxford.

(*Continued from page* 202).

We have now dealt with the leading principles that have emerged from the recent study of sex in animals. It remains to consider some special cases in the light of these principles.

The Gipsy moth does not stand alone in showing the progressive change of an animal from one sex to the other. Mrs. Sexton and myself, for instance, have examined a number of sexually abnormal specimens of the little amphipod crustacean Gammarus, and found a similar state of affairs. This animal has the additional advantage of moulting throughout life; and we have been able to show that these intersexes retain the same degree of femaleness throughout, but become progressively more and more male with successive moults. This can only mean that a certain degree of femaleness was reached, that the animal was then switched over to maleness, and that the male-determining substance afterwards progressively increased. It is further interesting in showing that the accumulation of male-determining substance may be very slow, and that the change from full female to full male may, therefore, take a very considerable time. A Gammarus intersex with partially developed male characters is therefore intersexual in rather a different way from any intersexual specimen of the Gipsy moth. Not only is it changing from the mode of working of one sex to that of the other, but it possesses a mode of working which is actually intermediate.

Then Crew has recently shown that almost all the so-called hermaphrodite adult frogs that are occasionally met with, are in reality individuals at some stage from the transformation from a normal female to a normal male.

This, however, seems only to be a rare and extreme case of a commoner phenomenon. Hertwig and his pupils have shown that some pure races and many crosses of different races of frogs give results very similar to that found in the Gipsy moth, reproductive organs often starting as female and after a shorter or longer time being made over into male. The changes that occur in the adult frog are only more striking and more general.

The chief points that concern us here are as follows:—First, since there are no hard parts whose form is fixed once and for all, the intersexuality can only be detected during the comparatively short transition period. Secondly, the developing organism is much more susceptible to external agencies than the moth. Optimum temperatures during development, for instance, favour the development of females, while extremes, both of heat and cold, favour the development of males.

Thirdly, it has been found possible to alter the sex-producing mechanism by delaying fertilization. If a pair of frogs are separated after a portion of the eggs have been laid, and the remainder of the eggs fertilized after the lapse of about four days, all the offspring are males. Considerable openings are given here for a study of the agencies which affect the production of the sex-determining substances in the developing animal. It has been supposed that in mammals a similar phenomenon occurred, and that if a female was served early in the period of heat a preponderance of females would result; if late, a preponderance of males. The latest statistics published by Pearl, however (*Ann. Rept. Maine Agric. Exp. Sta.*, 1917), indicate that in cattle this is not the case. In other mammals the period of heat is longer, and in them the matter should be put to a careful test by practical breeders.

Finally, it is of interest to know that the frog is the only vertebrate animal in which offspring have been raised from an individual which has been transformed from one sex to the other. Crew (*Journ. Genet.*, 1921) found that one of the parent frogs he had used in certain breeding experiments was recognisably in the last stages of transformation from female to male. While all the other pairs gave offspring with a normal sex-ratio close to equality, this pair gave nothing but females (in a total of over seven hundred). This

is what would be expected if the normal male frog had one X chromosome, the female two, since all the gametes both of the normal female and the female transformed into a male which fertilised it would contain an X, and all the offspring would therefore be XX—i.e., female.

Similar abnormal sex-ratios due to transformation of females into functional males have been obtained by Goldschmidt in his moths.

The marine worm *Bonellia* is interesting to us from more points of view than one. It is remarkable for its extreme sexual dimorphism, the female having a bulky body a couple of inches long, with an enormously distensible proboscis, while the male is a fraction of an inch in length, and spends his life as a parasite upon the female. Baltzer has found that in this animal sex is usually determined by an accident of position. The eggs of the animal hatch out into free-swimming larvæ. If one of these settles down upon the sea-bottom, it becomes transformed, after passing through an indifferent phase, into a female. But if it chances to settle upon the proboscis of a mature female (it is quite possible that the larvæ are in some way attracted by the proboscis), it turns into a male. It appears quite certain that any larva can become either a male or female, according to whether it does or does not settle upon a mature female. Baltzer took larvæ at various periods after they had settled upon a female's proboscis, but before they had become completely male, and forced them to lead an independent life. As a result, he obtained intersexual forms, the degree of intersexuality varying with the length of time the larvæ had been allowed to remain upon the proboscis.

It is important to notice that a small percentage of larvæ which do not settle on a female's proboscis may become males instead of females, and that the slower-developing individuals among the females often pass through a short male phase, characterised by the production of sperm. Goldschmidt advances an ingenious hypothesis to cover these facts. He supposes that in all individuals, there is at first an excess of male-determining substance, but that the production of female-determining substance after a time catches it up. Further, he supposes that the secretion of the female's proboscis has an effect comparable to that of the thyroid hormone upon tadpoles,

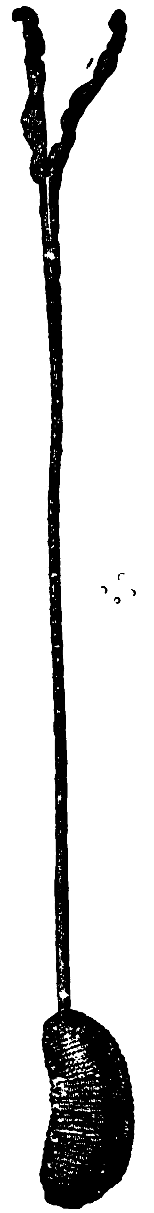

FIG. 7.—*Bonellia viridis*, female, about half natural size. The four small crescent-shaped bodies to the right of the proboscis represent males drawn to the same scale.

of accelerating the process of development and differentiation as against the, in many ways, antagonistic processes of growth. When differentiation is rapid, the sexual organs and the whole organisation mature under the influence of the male hormone; when it is not accelerated, under that of the female. There is nothing inherently

improbable in this view; and in any case the conception of processes succeeding each other in time, of a male phase succeeded by a female phase, appears to be necessary.

In any case, it is clear that there *need* be no sex-chromosome mechanism in *Bonellia*; the switch machinery is here provided by the outer environment of the developing creature.

The same possibility of dispensing with a sex-chromosome mechanism is seen in the slipper-limpet, *Crepidula,* which has become such a plague to the oyster-fisheries in certain districts. This animal forms chains, the free-swimming young settling upon older individuals and growing up where they settle. It has been established that the animal, after making itself fast, passes first through a neutral phase, develops then into a male, then becomes hermaphrodite, and finally ends its days as a female—a sufficiently adventurous history, if the animal were but capable of appreciating the fact!

In one species, *C. plana*, Gould has found that the male phase only occurs if an animal is attached to or near a larger (*i.e.*, usually a female) individual. If it is prevented from attaining this propinquity, it passes directly from the neutral to the female stage.

We are immediately reminded of *Bonellia*, and the dependence of its fate upon contact or non-contact with the proboscis of a mature female. A further parallel is afforded by the fact that the male phase in *Crepidula* is characterised by a very considerable retardation in growth-rate, which is temptingly similar to the acceleration of differentiation in male *Bonellia.*

It is interesting to note that there are other species of *Crepidula* in which chain-formation does not occur; the animals always start as free-swimming males, and always are transformed after a time into sedentary females. In *C. plana*, apparently, growth is too intense at first to permit of differentiation during the period of the male hormone's activity, unless slowed down by the secretion which emanates from the mature females.

It is important to notice how the same elements recur, even though the details are so different, in moths, in *Bonellia*, in frogs, and in *Crepidula.* There is first something given in the constitution, which in its turn brings about the formation of male and female-determining hormones. There is next the variable rate of production of these hormones, and, finally, the variable rates of growth on the one hand, of differentiation on the other.

I may be perhaps pardoned if I digress for a moment to point out the similarity of the factors of another interesting biological problem—that of metamorphosis. It has, of course, been known since Gudernatsch's work, that feeding tadpoles upon thyroid caused them to metamorphose precociously into frogs. Later research shows that here, too, there exist complex quantitative relations between rate of growth, rate of differentiation, and amount of thyroid substance present. Put in a rather unusual way, the facts are these. The animal passes normally through two successive phases--the tadpole phase and the adult. A certain type of metabolism characterizes the tadpole phase. One might possibly say that there are definite substances, the tadpole-producing hormones, circulating in the animal's blood. The thyroid is the organ which transmutes one phase into the other. Below a certain relative concentration of thyroid hormone, the animal remains a tadpole; once this relative concentration is exceeded, it becomes forcibly converted into an adult. By cutting out the thyroid, the tadpole phase is made permanent, and giant tadpoles, several years old, can be produced. By altering the amount of food and, consequently, the rate of growth, the time of transition is shifted. By adding iodine, the rate of production of the iodine-containing thyroid hormone is increased, and precocious metamorphosis results. By low temperatures, growth is favoured as against thyroid development, and the animals reach an unusually large size before they metamorphose. The main fact remains, namely, that there is a competition between two vital processes—the tadpole-producing processes on the one hand, the absolute and relative increase of the thyroid on the other, and that these are so timed by the inherited constitution that the latter catches up with and surpasses the former during development. It is probable that many other developmental processes have a similar basis. It will be seen that we are entering upon a new and interesting field of biological work — the chemical time-relations of development, which will be to biology what physical chemistry has been to chemistry at large.

It will not have escaped the notice of many of my hearers that the assumption of a specific "tadpole-determining" hormone, although a possibility, is not necessitated by the facts in the same way that the assumption of specific male and female-determining hormones are made necessary by experiments such as Minoura's on artificial free-martins in chicks. It is only necessary to think of one hormone, that of the thyroid, and two possible types of metabolism, one of which will occur when there is less than a certain relative amount of thyroid hormone, the other when there is more. Further, this explanation is equally applicable to cases such as that of sex in *Crepidula*— one type of metabolism leading to femaleness when there is less than a certain amount of the hormone secreted by the adult females, another leading to maleness when there is more.

That this is at least an alternative and equally fruitful way of regarding the facts, is shown by the recently published work of Bridges, again on the fruit-fly *Drosophila.* He discovered a strain which, by some abnormality of chromosome-mechanism, had become triploid—that is to say, it contained each chromosome in triplicate instead of in duplicate. By appropriate matings, it was found possible to obtain individuals which possessed either one, two, or three X-chromosomes in conjunction with three sets of *autosomes*, as the rest of the chromosomes are styled. It will be remembered that in a normal *Drosophila* two X's give a female, one X a male. In the triploid race, those with three X's gave females, those with one X (abnormal) males, and those with two X's were intersexes. It is thus clear that the determination of sex here is an affair of balance between the amount of a male-determining substance or substances, produced by the autosomes, and some other, female-determining, substance produced by the X chromosomes.

If we call the substance produced by the X-chromosomes χ, the autosomes A and the substance produced by them α, then a ratio of I χ : I α will give females (3X : 3A, or 2X : 2A); a ratio of I χ : 2 α or more than 2 α will give males (IX : 2A, or IX : 3A); and one of I χ : I.5 α will give intersexes (2X : 3A). There is further evidence, of a nature too complicated to enter into here, that the "male-determining substance" is not in reality simple, but depends upon a number of separate Mendelian factors scattered throughout the various chromosomes. In this case, it would be perfectly justifiable to say that there exist two types of metabolism, the one obtaining when there is less, the other when there is more than a certain relative amount of the "female-determining" substance contained in the X-chromosomes.

In any event, the work is of importance, because it shows that an intersexual condition may be produced by an accurate balance of male and female-determining substances, not necessarily by a switching-over from one sex to the other during development. We have therefore to distinguish "balanced intersexuality" as seen here, from "consecutive" or "developmental intersexuality" as seen in the Gipsy moth, Gammarus, etc. In other words, we have to distinguish two separate variables — first, the initial amounts of the male and

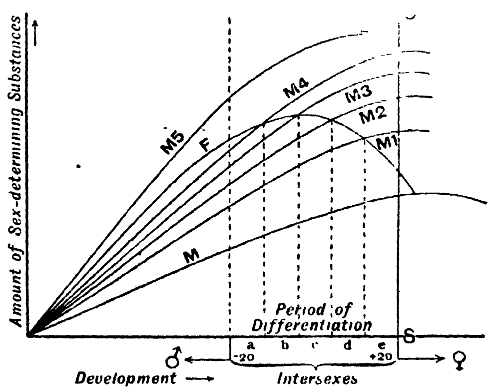

FIG. 8

female-determining factors in the inherited constitution, and secondly the different rates at which these produce male and female-determining substances during development.

Finally, another form of intersexuality, also found in Drosophila, must be mentioned. Sturtevant discovered a strain that was throwing intersexual forms; on analysis, it turned out that the abnormal condition was due to a mutation in a single Mendelian factor. All we can say at present is that this mutation in some way affected the metabolism so as to make it intermediate between the male and female types. It is of great importance, however, as proving that the most serious sexual abnormalities may be due to single mutations. In just

the same way, it appears probable that serious forms of feeble-mindedness in man may in certain cases be due, not directly to any defect of the hereditary constitution of the brain, but to a single mutation affecting the thyroid gland, and so indirectly the development of the brain.

In any case, the metabolism of male and female is often markedly distinct. This sex-difference of metabolism may be looked upon as the last stage in the chain of sex-determination. The hereditary factors are producing substances which lead to the production of male or female reproductive organs; these produce hormones which control other sexual characters, and interact with all the other ductless glands of the body; and this interaction results in a characteristic type of metabolism, different for male and female. It is, therefore, theoretically possible to alter the end-result—sex—by alteration of any of the links of the chain. One may alter the proportion or the rate of working of the hereditary factors, as in Drosophila and the Gipsy moth; or interfere with hormone-production, by castration, grafting, or possibly by acting upon other ductless glands; or finally, by acting upon the adult's metabolic processes. It is worth while insisting upon the existence of this chain, since its earlier links are often ignored by physiologists, its later links by zoologists.

As showing what fields for investigation are here opened up, I would like to mention a few facts illustrating the difference of metabolism which does exist between male and female of the same species. The blood of different species of insects, as in other groups of animals, often gives a precipitate when mixed with the blood of another species. A similar, often considerable, precipitate, is in many cases given when the blood of a male is mixed with that of a female insect of the same species. In Drosophila, the females hatch out before the males. When intersexes are present, their rate of development is intermediate. In the human species the basal metabolism of woman, when all corrections have been made for surface and weight, is less than that of man. In the Gipsy moth the whole metabolism is more active in males than in females, not only in the caterpillars at all ages, but also in the pupæ. To use the old terminology of Geddes and Thomson, the male is more katabolic, the female more anabolic. A somewhat similar sex-difference exists in bees. The grub that is to produce a drone stores up glycogen and fat much more rapidly than the grub destined to produce a worker-female, and uses up these reserves much faster during the pupal period.

That an interference with metabolism may cause partial or total sex-reversal is shown by a number of facts. In the first place there exists the phenomenon known as parasitic castration, in which the presence of certain parasites re-acts upon the sexual characters of their host. This term is really a misnomer, since the atrophy of the reproductive organs is only one of the effects produced; "parasitic sex-modification" would be preferable. The best known example is that of the parasite Sacculina, which inhabits various species of crabs. Geoffrey Smith investigated very carefully the effects produced. He found that while in both sexes the reproductive organ was destroyed by the presence of the parasite, no other change was produced in the female, save that young females took on the female adult sex-characters more rapidly than normal. Parasitized males, however, gradually take on more and more of the female characters—their great claws grow smaller, their abdomen broader, their swimmerets enlarge and become fringed with the hairs to which in the female the eggs are attached. Most infected animals die; but in a few the parasite disappears, and the reproductive organs are then regenerated. Such animals, if females, regenerate a normal ovary. Males which have only been partially modified towards femaleness regenerate a normal testis; but those which had assumed full female sex-characters regenerate a reproductive organ in which both eggs and sperm are to be found, showing that their metabolism has been altered so that it has become actually intermediate between male and female. That the effects are not due to castration alone is obvious from the facts we have just mentioned. It is further definitely proved by what is known in insects, in which, as we have already seen, castration itself has no effect upon the remaining sex-characters; in other words, a sex-hormone is not produced by the reproductive organs, but, if it exists, by the body as a whole, under the direct influence of the sex-chromosomes in the cells of the various tissues. In spite, however, of this lack of dependence of sex-characters upon the reproductive organs, the presence

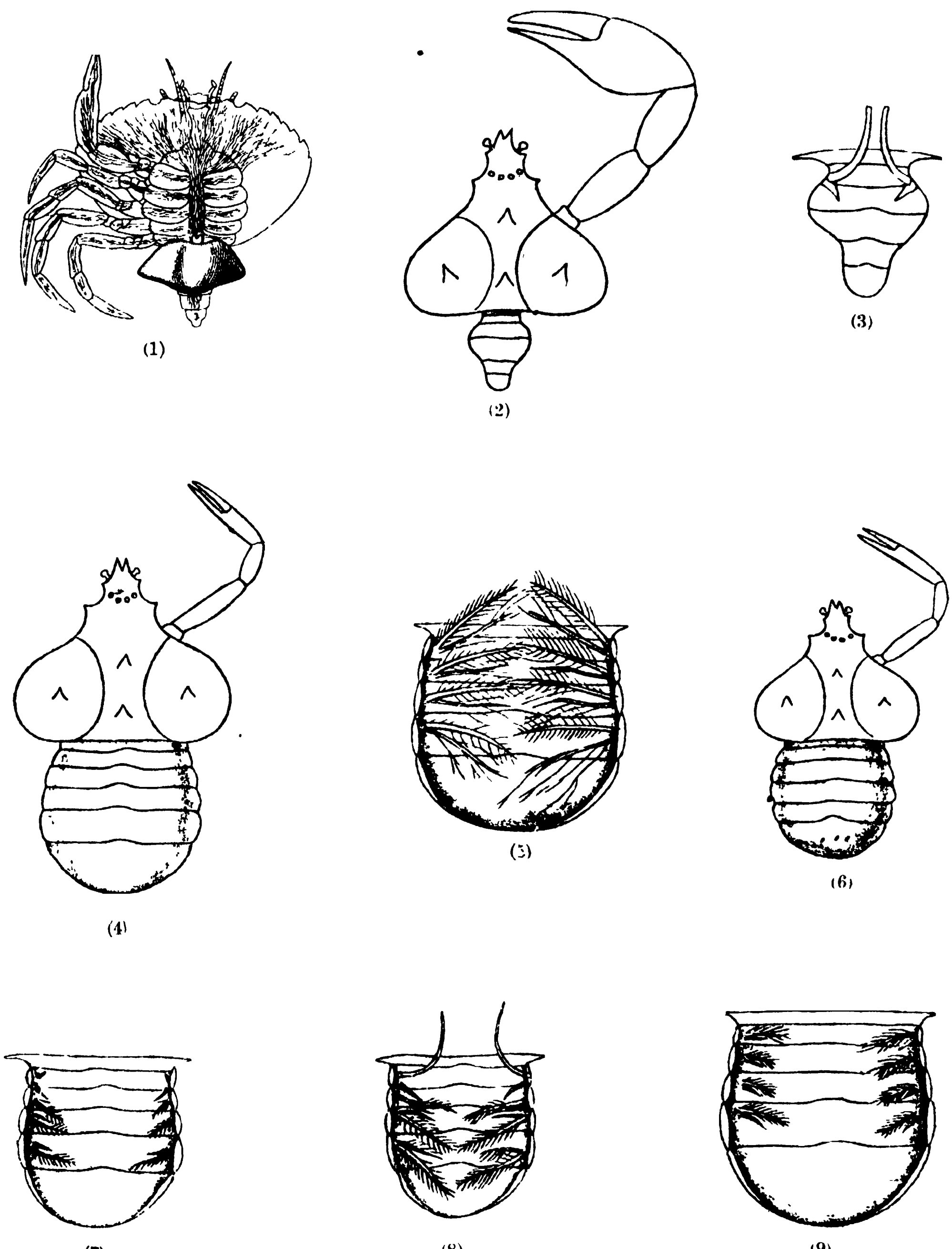

Fig. 9.—*Sacculina* and its effects on its host. (1) Diagram showing a *Sacculina* attached to the under side of the abdomen of a Shore Crab, with its roots ramifying in the body and limbs of its host. (After Delage). (2. 9) Spider Crabs, *Inachus dorsettensis*. (2) Normal male, (3) Under side of abdomen of normal male, showing copulatory styles. (4) Normal female. (5) Under side of abdomen of normal female, showing feathered appendages for carrying the eggs. (6) Sacculinized male. (7, 8) Under side of abdomen of two sacculinized males, showing reduction of copulatory styles and development of feathered appendages (9) Under side of abdomen of sacculinized female, showing reduction of appendages.

of parasites may cause male insects to assume female sex-characters.

Finally, Smith showed that the crabs which harboured Sacculina, whether male or female, had circulating in their blood large amounts of certain fatty substances which in normal animals without the parasite only exist in the female sex.

Some very interesting work on fowls, as yet unpublished, which I am able to mention through the kindness of my friend, Dr. Crew, shows that in birds also sex may be influenced in this way. It has been known for some time that old hen birds of various species may assume male plumage. Crew has collected a number of such specimens in fowls. He finds that two separate groups can be distinguished. In one, the ovary is undergoing simple atrophy. These birds show a rapid assumption of male-type comb and wattles, a slow assumption of male plumage, but neutral behaviour. Similar results have been obtained by others by simple removal of the ovary, whose hormone thus normally prevents the development of certain of the male sex-characters. In the other group, however, the assumption of male plumage is much quicker, and the bird soon becomes almost indistinguishable from an ordinary cock. What is more, she (or he, or it!) begins to crow lustily, to fight with other cocks and to behave as a cock towards normal hens. In all such birds, the ovary has been found to be the seat of a tumour. There can be little doubt that the tumour is here playing a rôle very similar to that of a Sacculina in a crab, and is altering the whole internal environment of the creature so as to make it unfavourable for the persistence of the female organs and characters, favourable for the expression of the male characters, hitherto latent in the chromosomes. A few cases are on record where female birds which have assumed male plumage have actually developed spermatozoa in place of eggs in their reproductive organs. It remains to be seen whether, as is probable, this is the end-result of the changes produced by ovarian tumours. In any case, it is established that changes in metabolism, in the delicately-adjusted internal environment of higher animals, may produce profound alterations in sexual characters. The mere fact that sperm can be produced by a previously normal hen shows that the attainment of a stage in which sex-hormones are actively produced by the reproductive organ need not prevent the ultimate reversal of sex; and they raise the interesting possibility that we may be able to find substances whose injection, even into the adult organism, may bring about a change of sex.

These fowls raise interesting questions for the psychologist. Here is an animal with a certain modicum of memory; it has been a hen, with the instincts and habits of a hen, all its life. Then comes a change of reproductive organ, a change of sex-hormone, and all its past appears to vanish, and to be superseded by totally new habits, which seem equally automatic of acquirement in old age as in youth. What has happened to the memories of the hen's life? It is at least a reminder of the degree to which mental processes and behaviour are under the control of chemical substances.

We must now turn to a special consideration of mammals and to man.

There is one subject which we have so far not dealt with—the seasonal variation in sex-ratio in various mammals. Statistics show that in Cuba, the seasons of highest birth-rate are those with lowest proportion of males, both in white and coloured people. If females are taken as 100, the difference in proportion of males is 104 as against 108 in whites, 99 as against 108 in negroes. Precisely similar figures are found for other mammals, although the difference may be far greater. In the greyhound, for instance, most young are born in the months March to June; the ratio of males to 100 females during these months varies from 113 to 119, while during the rest of the year, it varies from 128 to 195.

These results have received confirmation from the accurate work, carried out on pedigreed stock under experimental conditions, of Miss King on rats. Her facts are seen at a glance in the accompanying curve.

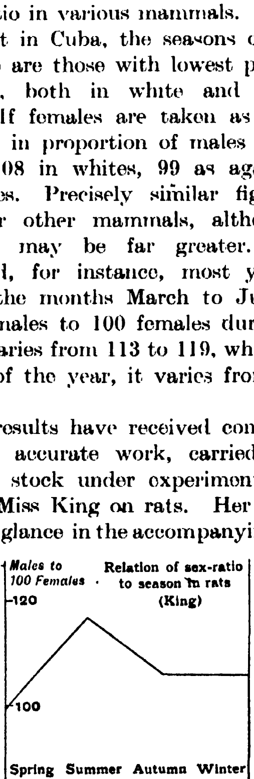

FIG. 10.

There is further some evidence that sex-ratio differs with the age of the parents,

the proportion of female children in man being greater when the mother is young. The old belief that war increases the proportion of males among offspring seems to find definite confirmation in the statistics recently published by Savorgnan (Metron, 1921). The increase, however, though definite and constant, is slight, amounting only to one per cent. or less.

The only evidence that large changes in the sex-ratio may be brought about in man is given by the recent and as yet unconfirmed work of Siegel (Münch: Med: Wochenschr: 1916), based on statistics collected during the war upon children conceived when their fathers were home on leave for short periods. Siegel finds a very marked correlation between the probable sex of the offspring and the time during the menstrual cycle at which impregnation and fertilization occurred. The diagram will give in condensed form the results of his investigation. It will be seen that children arising from an impregnation soon after menstruation (which is probably the period just before ovulation) are preponderatingly males, while impregnation during the period from the 15th to 22nd day (probably the period just after ovulation) gives a large preponderance of females. The number of cases is small, but if the facts are accurate, the difference of sex-ratio undoubtedly exists.

Time of Impregnation (days after onset of menstruation)	Offspring.		% Males
	Male.	Female.	
1st—9th	37	7	84%
10th—14th	4	9	31%
15th—22nd	3	20	13%
23rd—28th	—	—	—
Total (80)	44	36	55%

Relation of Sex of Child to time of impregnation (man). (After Siegel.)

Siegel believes that this is due to different degrees of ripeness in the ovum, and fortifies his contention with the researches of Hertwig upon fertilization of over-ripe eggs in frogs. It should be borne in mind, however, that very little certainty has yet been reached as to the exact time during the menstrual cycle at which the human ovum is liberated. In any event, the statistical results, so far as they go, are of the highest interest, and if they turn out to correspond with reality, will pave the way for a very large measure of practical sex-control in the human race—a serious matter, for if not properly regulated, it might bring about the most revolutionary social results.

There is, however, another possible theory to account for the facts. We have already seen that the male sex is often characterised by the possession of one chromosome less than the female, and that when this occurs, there will be two types of sperms, one with, the other without, an X-chromosome. Since it is the chromosomes which constitute the nucleus, and since the so-called "head" of a spermatozoon is simply a condensed nucleus, we might expect to find the difference in chromosome-number between the two sorts of sperm reflected in a difference in size of sperm-head. This is actually the case. In many insects, in the bull, the pig, the horse and other mammals, the two types can be readily distinguished. If a number of sperms of such animals are measured, they fall into two size-groups, while sperms with no chromosome difference show only one peak to their variation curve. When there are these two types of sperms, the large ones are female-determining, the small ones male-determining. From the available evidence, it is highly probable that spermatozoa of two sizes also exist in man.

Now if there are two types of spermatozoa, they may swim at different rates in their long adventurous journey to find the ovum in the upper recesses of the Fallopian tube, or they may be of differing susceptibility to various agencies. Further, it is more than possible that the conditions for their journey within the body of the female may vary considerably at different times of the menstrual cycle; and if this is so, the female-determining sperms might well be favoured at one time, the male-determining at another. Here again there is a large field for experiment.

In plants, it has already been shown by Renner and others that pollen grains containing different hereditary factors may differ in their rate of growth from the pistil to the ovules; and in the Campion, where there are known to be male and female-determining pollen grains, Correns has shown that these have different growth-rates, and that the difference may be increased or decreased

by various circumstances, giving rise to differences in sex-ratio. In animals, there is evidence that the female-determining spermatozoa (in guinea-pigs) are more susceptible to the effects of a poison such as alcohol than are the male-determining.

If Siegel's results cannot be interpreted on the assumption that the difference in sex-ratio is due to differing susceptibility or activity of the two sorts of spermatozoa, then it is very difficult to understand why there are not very frequent exceptions to the rules of sex-linked inheritance in man. But, as a matter of fact, these pursue their normal course. One of our previous diagrams shows the pedigree of a family in which haemophilia is prevalent. As will be seen, the disease is transmitted through females, appears in males and from them passes to their daughters only; this, of course, is what would be expected if the disease was due to a recessive factor lodged in the sex-chromosome, and if women were XX in constitution, men X or XY. Exceptions to this rule do occur, in animals as in man, but they are very rare. In any case, the fact of the existence of different-sized male and female determining spermatozoa in mammals opens up all kinds of possibilities. It should prove possible to separate the two kinds artificially, and then, by means of artifical insemination, to control the sex of the offspring.

There remains the possibility that in mammals, as in moths and frogs, occasionally individuals which have the chromosome formula of one sex may be converted into functional individuals of the other sex. If this is so, they should, as we have seen, give an abnormal sex-ratio in their offspring. If they are XX individuals functioning as males, their children should be all females, if the reverse, their children should be 66 % males. Statistics could here be called to our aid. An analysis of the sex-ratio among the parents and offspring of families consisting entirely of one sex is needed. Similarly, if the slight increase in the proportion of males consequent upon the war be due to such a sex-reversal, then there should be a corresponding increase of females in the next generation, some twenty to forty years hence.

There can be no doubt, however, that partial sex-reversal in man may and does take place, leading to the production of intersexes (usually referred to in the medical literature as pseudo-hermaphrodites). New light is thrown upon this dark medico-legal subject by the biological conception of intersexuality. Both when intersexuality is caused by hormones, as in the free-martin, or when it is caused by the blending of unbalanced sex-factors, as in the Gipsy moth, all stages are to be found in the conversion of one sex into the other. Thus, even when a human intersex is predominantly male, it (as we had better provisionally style the intersex) may have started as a female. The study of human intersexes is beset with the greatest difficulty. They may be due in some cases to the failure of the mechanism which normally prevents male embryos from being affected by their mothers' female-determining hormone; or (most probable explanation) they may be due to the combination of mal-adjusted sex-factors, or to a single Mendelian mutation.

It is important to note that a complete transition exists in man from very slight degrees of intersexuality, where only the sexual instincts seem to be affected (and here it is interesting to find that most modern authorities hold that most cases of sexual perversion are due to inherited causes) through advancing degrees of so-called pseudo-hermaphroditism, in which various stages of physical intersexuality occur, to complete hermaphrodites. This complete transition is paralleled by the transition in Goldschmidt's moths.

It is not only perfectly possible, but even probable, that mal-adjusted sex-factors may exist in man as in moths; but the end-result will not be the same in man, because of the existence of the hormone produced by the reproductive organs. It is probable that a relative excess, say, of female-determining factor in a male embryo, would lead to a condition in which the reproductive organ was slightly intermediate at the time when it began producing its hormone, and that this intermediate or intersexual condition would, by means of the hormone, be maintained at the same level throughout life.

Several results follow from such a consideration of human sexual abnormality. The first is therapeutic: there is a distinct theoretical possibility that cases of sexual perversion might be cured by injection or grafting of the proper reproductive organ. Goldschmidt has already drawn attention to this, and I believe that the suggestion is being tested in Germany. The second is legal: it is highly probable that human intersexes

are neither male nor female, but definitely intermediate in sex. If so, then it must be wrong to assign a normal sex to them legally, for they belong to a third category, and if this category is biologically a real one, as is certainly the intersexual category in moths, then the law should recognize it. The third is ethical: we are accustomed to visit departures from sexual normality with legal penalty and moral censure. If, as seems highly probable, many of the individuals who thus depart from the normal are not morally perverted, but simply in the grip of blind hereditary forces, of whose results alone they are aware, then it is clear that a new standard is needed with which to measure the whole matter.

In conclusion, I may remind my hearers that twenty years ago we knew nothing whatever of any of the chief facts which I have dealt with in this lecture. In that short period we have, as I hope I have been able to show you, gained definite information on many of the links of the causal chain determining sex. Many workers, it is true, had advanced views often similar to those I have laid before you; but these were the result of guesses, even if of inspired guesses. The causal mechanism was still unknown; and, as Bacon put it once and for all, *vere scire est per causas scire.*

The difference between the sex-chromosomes of polar body and egg in moths and birds; the differences between male-determining and female-determining sperms in some insects and in mammals; the differing rates of working of the sex-factors in different geographical races; the existence and method of working of sex-hormones, particularly in mammals; the difference between male and female metabolism; in all these fields we are at last in possession of definite facts, and facts which, in the long run, are bound to lead to practical control. Scientifically staffed institutions, where theory may join hands with practice, will accomplish for animal breeding, and for eugenics, what the works laboratory and the research association are doing for applied chemistry. Knowledge is, in the long run, always power. If you are convinced of this, and if I have convinced you of the rate at which our knowledge of this particular problem is growing, I shall be content.

I wish to end this lecture by making three appeals. They are for the recognition of biology on an equal footing with chemistry and physics, on the one hand as an exact science; on the other, as an indispensable pillar of modern civilization. Physiology during the last half-century has applied increasingly exact methods to certain biological phenomena, but study of the most fundamental processes of life has scarcely passed beyond the observational stage. By fundamental processes I mean those in which living units—whole organisms—are concerned; processes which are to the last degree complex from the standpoint of inorganic chemistry and physics, but are unitary and simple from the standpoint of biology as a science of organisms.

I should include, under this head, in the first place, the physiology of whole adult organisms; this is largely a study of organic regulation. The realization of the function of the ductless glands, of the protective reactions of the blood and tissues; the analysis of the working of the central and sympathetic nervous systems, were necessary before even an idea of the gross regulation of a vertebrate's life-processes could be formulated. Before what we may call the microscopic analysis of these processes can be attempted, a considerable study must be made of enzymes, of the colloid state, of bio-chemistry in the narrower sense, of immunity reactions.

It could not begin to progress until after the functions of ductless glands were realized, and is yet in its infancy.

Secondly, the physiology of development—the study of the changes by which the simple ovum, passing through forms of greater and greater complexity, becomes converted into the adult; the study of regeneration, of budding, of developmental reversal and regression. This is largely a study of the regulation of form. Forty years ago this field was scarcely touched. To-day we have reached certain broad principles in regeneration and experimental embryology, we have been introduced to new horizons by the study of artificial parthenogenesis and of tissue culture, we have amassed a multitude of facts. But the complexity of the subject is even greater than that of adult physiology, and the unifying principles needed to correlate the various facts even more to seek.

In the third place, there is the study of heredity, which in its turn is mainly a study of the regulation of species—their constancy and their power of adaptation. On the one hand, the discovery and detailed

study of the chromosomes, which in its turn depended on the perfection of microscopic technique; on the other, the discovery that the hereditary constitution was composed of separate factors united in definite relations of proportion and place; these, together with the discovery of mutation in the factors, were needed before the study of heredity could become in any sense scientific.

Fourthly, we have the study of organic evolution—the regulation of life in its totality. The study of fossils, of geographical distribution, of variation, of adaptation has opened a window here and there to our ignorance, but we can scarcely be said to have advanced materially in our views of evolution since Darwin's day. The laws of the genesis of species, the study of natural selection, the succession of types, the whole concept of biological progress—all these subjects await the vivifying touch of the experimentalist and the mathematician.

What I am here concerned to point out is first that the prolegomena of an accurate biology are all biological—ductless glands, colloids, enzymes, chromosomes, nervous regulation, and the rest. Physics and chemistry would not have led on to their discovery and intensive study; but biology has opened up whole new fields in which the methods and the knowledge we already possess of physics and chemistry can now profitably be employed.

Biophysics and biochemistry will, as time goes on, afford the most interesting and intricate problems for the physicist and the chemist. My appeal is partly to the chemists and physicists, that they may realise the exactitude to which biology is tending, the part she can play in presenting them with problems of unsurpassed interest, the duty they have towards her.

It is secondly to the representatives of scientific medicine. There is at present in this country a tendency for medical research to become more and more biological. This is in itself a wholly admirable tendency; but it is dangerous in so far as it induces biology to become more and more medical. Through its power and practical importance medicine can establish a medical point of view in biological thought; and the medical point of view is in the nature of things narrower than the biological. It is through the study of biologists upon flies that new vistas in heredity have been opened up by the establishment of the chromosome theory; by their work upon moths, as we have seen to-day, that wholly new ideas upon sex have been reached; by their experiments upon Amphibia that new accuracy and new speed have been introduced into the study of the effects of the ductless glands. The medical point of view must inevitably be dominated by the study of human and mammalian physiology; pure biology, busy with nature's myriad types, must continually be lighting upon more favourable material, upon new points of view.

Finally, my appeal is directed to the general public, and especially to that part of it which is concerned in the shaping of opinion and of policy; it is an appeal to realise the importance of biology to national and general civilisation and progress. Pasteur's work on spontaneous generation led to the foundation of the whole science of bacteriology; Metchnikoff's observation of phagocytes in a starfish larva provided the impetus to great advances in the study of immunity; the desire of Mendel, of Bateson, of Baur, of Morgan to comprehend the nature of heredity has laid the basis of new methods of animal breeding, and given us hope that Eugenics may become a matter of practical politics; the debt of medicine to physiology is a commonplace, but none the less vast for that.

The work now being done at Rothamsted and elsewhere upon the bacteria of the soil is bound to lead to improvements in agriculture, while the science of bacteriology has revealed various chemical aptitudes of micro-organisms which may be of the greatest practical utility to man in his attempts to synthesize useful substances.

The pure desire for knowledge, the pure pleasure in discovery, will always contribute its share to results of practical importance, to essential progress; together with the direct desire to achieve a definite practical result. Judging by the facts of history, it will continue to contribute the larger share.

There will never be a lack in this country of those who are eager to carry on the work of discovery for its own sake; but the technical difficulties in the way of progress increase with progress itself, in biology equally with chemistry or physics. The keeping of animals, and especially the breeding of them on a large scale is expensive and often difficult; the education of good biologists is lengthy and costly; the number of different techniques which are needed to

bring a large biological problem to a conclusion is very great.

Chemistry and physics are the agencies by which we obtain control over our lifeless environment. Biology, in its widest sense, is the agency by which we obtain control over life, our own life included. I see many signs that the older divisions of biology are melting away. Physiologists are turning more towards the lower animals; zoologists are supplementing the methods of comparative anatomy by those of physiology; the geneticists are confounding botany and zoology in their single science. Everything points to the reintegration of a science of pure biology. And it is for a fuller recognition and appreciation of this science that I plead.

[Figures 1, 2, 4, 7 and 9 are taken, by permission, from "The Determination of Sex," by L. Doncaster, Sc.D. (Cambridge: at the University Press, 1914); and Figures 3, 5 and 6 from "Mechanismus and Physiologie der Geschlechtsbestimmung," by Prof. Dr. Richard Goldschmidt, Mitglied des Kaiser - Wilhelm - Instituts für Biologie, Berlin - Dahlem. (Berlin: Verlag von Gebrüder Borntraeger. 1920). For further information reference should be made to the above named general text-books.]

DISCUSSION.

The CHAIRMAN (Dr. Chalmers Mitchell) said he was afraid if any had come to hear the extraordinarily interesting paper Mr Huxley had read with the idea that they would go away with a receipt for determining the sex of their next baby, or whether they were going to have more male or female calves in their farmyard stock, they would be disappointed. On the other hand, if they had followed even a portion only of the extremely interesting though complicated facts the lecturer had placed before them, they must realise that although, at the moment, science was not able to give practical results of that kind, it was rapidly approaching a stage when that might be possible. He would like to give one or two reasons, gathered from the lecturer's remarks, in support of that possibility. It appeared to be the case that the primary distinction of sex—the possession of the male or female reproductive organs—depended on the presence in the sexual cells of a particular enzyme, a particular ferment or chemical material which, in all probability, was stored up in the odd chromosome known as the X chromosome. While on that point, there was one criticism he wished to make. In so fundamental a thing as sex—a thing that went right back to almost the lowest known organisms—he would be, *a priori*, rather surprised to find that there were different ways of determining it. He found it very difficult to believe, for instance, that birds and moths determined it through the female while mammals and some insects determined it through the male. One would expect so fundamental a distinction, which had existed from the very beginning of the living world, to work right through by more or less the same mechanism and to obey the same laws throughout the animal kingdom. It was exceedingly rash, he was well aware, to raise an *a priori* objection in biological questions, because so many strange things were being discovered that one was liable to go wrong. It appeared to be the case that the primary distinction of sex was determined at the time of fertilisation, and that the mechanism was so adjusted that under normal conditions on the average there would be an equal proportion of males and females. It had been clearly shown, however, that that equal ratio of male and female could be altered experimentally in certain cases—in some by an alteration of temperature, in others by retarding the time at which the egg was fertilised; so that, right at the beginning, there was definite experimental evidence that one could control, in certain cases at least, whether the ratio was to be equal or to dip towards one side or the other. Once the primary distinction between the sexes was determined, internal secretions or hormones were liberated which began to control the other characters of the body—not merely the primary sexual characters, but all the other characters associated with sex. Then, again, it seemed to be definitely proved that the rate at which the male-determining hormone or the female-determining hormone developed varied with conditions which were subject to experiment and could therefore be altered, so that not only primary but apparently secondary sexual characters were subject to experimental change of the natural ratio. There was a very great difference between the primary sexual characters and all those secondary sexual characters, and it certainly did not seem to follow that although one was able to change the secondary sexual characters one was going to make any difference to the primary sexual characters. He gathered that in the case of insects there was practically no relation between the primary and secondary sexual characters, whereas in vertebrates there was a very definite relation between them. That seemed to show that in the case of individuals which were neither male nor female, but partly each, and which were known by the rather awkward name of "intersexes," there were two entirely different things to disentangle. There was the possible transformation of the primary reproductive organ of one sex into that of the other, or—as seemed more probable—the replacement of one by the other. The alteration of the secondary sexual

characters was an entirely different matter. When dealing with the very difficult and interesting question of "intersexes" to which the lecturer had alluded, it had to be borne in mind that the idea was by no means so new as the Mendelians appeared to think. It was many years since the famous Danish naturalist Steenstrup, of Copenhagen, first propounded the theory that sex was distributed all over the body, and in different proportions in different individuals, and that, quite apart from the primary sexual character, there were those secondary sexual characters mingled throughout. A little later, but before any of the recent work (which had, he thought, been a little over-emphasised), a German named Otto Weininger wrote a very elaborate book on sex, in which he worked out at great length the relation of internal secretions to the primary maleness or femaleness of the different parts of the body, and discussed at considerable length a number of problems which modern workers were now submitting as entirely new discoveries of the Mendelians. He thought the work of the Mendelians was of very great interest, and might lead in the future to results of great importance. All those who had heard Mr. Huxley's paper that evening must be greatly indebted to him for it, but personally he hoped people would not go away with the idea that an entirely new line of discovery had been opened up and that the world was going to be transformed, the criminal law amended and many other things happen simply because some flies had red and some had white eyes, and because they behaved curiously in bottles in American laboratories.

MRS. R. HAIG THOMAS said she had carried out a number of experiments in breeding pheasants, and in nearly every case it had been found that the female offspring followed, both with regard to their primary and secondary sexual character, the characters of their father's mother.

DR. L. T. HOGBEN said the Chairman had mentioned that he found difficulty in attributing to birds and moths a different method of sex determination from that which obtained in the case of the majority of other animals investigated. But, if he might amplify a point which had been already made by the lecturer, it must not be imagined that the evidence regarding the difference in the method of sex determination between moths and birds on the one hand and men and flies on the other was obtained solely by examination with the microscope: it could be deduced from the facts of sex inheritance, from breeding experiments, quite independently of any microscopic data. Moreover, whether those results were represented by means of the elaborate Mendelian nomenclature or not, the fact that certain characteristics existed in birds which the female could only transmit to her sons did indicate the existence of two kinds of ova, while the fact that certain characteristics existed in flies and man which the male could only transmit to his daughters did indicate, apart from microscopic evidence, that there were two types of sperm produced. Under those circumstances, he did not think it was fair to raise an *a priori* objection.

DR. M. J. ROWLAND asked whether there was any truth, and, if so, what was the reason for it, in the popular belief that, after a period of warfare, there was an increase in the number of males born as compared with females. Could it be ascribed to lack of proper food? As a large breeder, breeding some 2,000 animals a year, he had recently been experimenting with the question of vitamines, and had found they had a marked effect on the prolificness of an animal. In the case of a herd of pedigree middle white pigs, the average litter, with ordinary feeding, consisted of about seven animals; but at the present time, after feeding with the three vitamines, the litters had attained such a size that it was felt unwise to proceed further; nineteens and twenties, and even twenty-ones, were quite common. Some time ago he purchased a number of pigs, in order to test his theory, from people who had kept them, according to the old filthy custom, in styes. He tested the food those animals had been getting, and found it deficient both in fat-soluble and water-soluble vitamines. They were having litters of three, four or five. Whether it was due to better class feeding generally or the presence of vitamines in the food it was impossible to say, but he was already getting litters of fourteen and fifteen.

MR. G. C. ROBSON said he had been informed by various breeders of pigs that the statement the lecturer had made with regard to the time of fertilisation also held good with regard to those animals. He believed, also, it had been found by Pearl and Parshley to hold good in the case of domestic cattle. In his very able book on the determination of sex, Doncaster laid down the generalisation that in some cases the sex ratio was exclusively determined by the composition of the gametes, but that in other cases, where the organism might be said to be in a more unstable physiological condition (chromosome differences between the sexes being slighter) it might be regarded as being more susceptible to environmental factors. That was written eight years ago, and he would like to know whether Mr. Huxley regarded it as shaken in any way by modern experimental work.

MR. G. W. OVERMAN said he had attended the meeting that evening in the hope of adding to the little knowledge he had gained by ex-

perience with horses and cows. He had been studying the problems connected with the breeding of horses and cows for the past twenty years, and he had proved that sex followed sex. If a cow had a heifer calf to-day and was mated next time mating commenced she would have a heifer calf again, but if she was passed over she would have a male calf. The same was true of horses. What he had said was true of cross-breeds; he did not know whether it would apply to pure bred animals. His system very rarely failed, and he would be interested to know if anyone else present had tried it. Mr. Spencer, a friend of his (Mr. Overman's) father, read a paper forty years ago to the Board of Agriculture on the same subject. He himself had been taught the system by his father about forty years ago. He had had a cow which dropped four heifer calves; three of them lived and all three bred. Was that usual when there were so many females? He knew when there was a male and a female the female did not breed, and thought it rather unusual for all three calves, born under the circumstances he had mentioned, to breed.

MR HUXLEY said there would be no difficulty in that.

MRS M HUNTER said she was only a very small breeder, but had been breeding pedigree Jersey cattle for the last six years About four years ago she heard of the system the last speaker had described, and since then had followed the same methods with the same excellent results; she had always had heifer calves when she wanted them.

DR H CORNER said that to a certain extent he also was a breeder of cattle and other stock, and had, in a small way, tried the same experiment as the two speakers who had preceded him, but he was not quite so enthusiastic about it as they were. The first time he tried it he was very successful, but latterly it had not worked so regularly. Everyone present was probably familiar with the work of Mr. Bonhote with regard to the determination of sex. That gentleman found by experiment that with a reduction of vigour he got many more males and with high vigour many more females, and his own experience supported that contention. It was well known, in the case of cattle, that the old cows threw bulls. Old cows, of course, were beginning to fail in vigour, and therefore should throw males according to Mr. Bonhote's theory. There was a great deal of evidence, into which he could not go that evening, to show that the female required much more vigour for the development of her femaleness than did the male for his maleness. One of the difficulties met with by those breeders who were aiming at high milk records was that when the cow was exhausted by that process she threw bulls With regard to sex-linked characters, so called, if those characters were sex-linked they should be always sex-linked, but they were not. It had been clearly shown that characters which were supposed to be sex-linked could be produced in the opposite sex by the reduction of the vigour of the parents. Mr. Bonhote had shown that. It was Miss Wilde, he believed, who had become famous through producing the male tortoise-shell cat, a great rarity. That had been done through in-breeding and reducing the vigour The same was done with pigeons. Fanciers who wanted to show a silver male, for example, bred a blue cock to the silver hen; from the progeny they selected a blue son which carried the dominant, and they bred back the hybrid blue son to its own mother. Mr. Bonhote had definitely proved that Mendelism did not hold good in such cases; he had experimented with rats and succeeded in effacing the dominant. He had recently been studying the inheritance of high production in dairy cattle, which is transmitted through the male and appears in the female, and his explanation was that the high-producing cow had her vigour reduced, first by the development of her femaleness, and subsequently by her excessive lactation, the result being that the daughters of high-producing cows were only moderate dairy cattle, as they had not enough inherited vigour to be able to express that quality, while their sons transmitted "high production" because the development of their maleness used up less vigour and so left more vigour for the development of other qualities. Cattle, being mammals, should, according to the lecturer, transmit their "sex-linked" characters through the female and these should appear in the male, but this is contrary to the experience of all breeders of dairy cattle. The tortoise-shell cat already referred to was another example of a character (tortoise-shell) being transmitted through the male and appearing in the female, and it would be interesting to know whether the chromosomes in cattle and cats differed from those in other mammals and were the same as those found in birds and moths.

MRS. A. SOAMES said she was a breeder of goats on a large scale, and got an enormous number of hermaphrodites. She would like to know the reason: was it due to tremendous in-breeding? She had been told that goats were the only animals affected in that way.

MR. HUXLEY, in reply, said the point raised by the last speaker was of great interest. Hermaphroditism did occur with goats, and seemed to be of the same nature as intersexuality in moths. The question of vigour in cattle or other animals was an exceedingly difficult one, because it was hard to measure vigour; it was largely a matter of opinion. With regard to the question of producing one

sex continuously by always utilising the immediately-following period, he thought all scientists would welcome detailed figures on the subject. Practical breeders did not always, he thought, realise the need for detailed figures. It was necessary to have large figures before one could exclude the possibility of chance, and if practical breeders wished to do a great service both to breeding and to the science of genetics they should collect detailed figures of sex relative to age of cattle and goats, relative to vigour (if they could give any details), to time of service and so forth, and send them to such people as Professor Bateson, of the John Innes Institute. He knew, also, that the gentleman who edited the *Journal of Genetics* would welcome them It was true, as Dr. Rowland had suggested, that there was an increase in the proportion of males born after a period of war. The increase was very slight—about 1%—but, curiously enough, it did not occur in all those countries which had suffered privations on account of the war. It was difficult to understand the reason.

Finally, if he might reply to the Chairman's criticism, he did not wish to claim any extraordinary novelty for the ideas he had set out. He thought the real distinction between the pre-Mendelian school and those who came after them was that while the former doubtless had an intuition of reality, people nowadays, for the first time, actually saw and knew the mechanism which was working to produce the observed results, and to find out a mechanism was eventually to control its workings.

On the motion of the CHAIRMAN, a hearty vote of thanks was accorded to Mr. Huxley for his paper. The proceedings then terminated.

NOTES ON BOOKS.

ATOMIC THEORIES.- By F. H. Loring. London: Methuen and Co., Ltd., 1921. 12s. 6d. net

In these days of consideration for the pounds, shillings and pence, we may perhaps be excused for noting with satisfaction that the price for a work of the present scale, scope and quality, is low if measured by to-day's rates; a fact which gives ground for congratulation to the publishers, and which may afford good augury as regards the prices of the higher grade books in the near future. The present book consists of 218 + X. large octavo pages, with 66 figures in the text, and the price is 12/6 net.

Our feeling of satisfaction at the lowness of price implies a somewhat hearty approval of Mr. Loring's work, as an unsatisfactory book is dear, even at a low price. The author takes his readers faithfully and well through the difficult and narrow way of recent research and speculation as regards atomic constitution, and in turning over the pages a first impression of the reader will be a sentiment of satisfaction at the large amount of detail as to recent aspects and researches.

Study of the Kinetic theory of gases (p.3) is a good introduction, and it is pointed out in what sense the four gas laws may be inexact: disturbances arising which may perhaps be termed "inter-gravitational," for want of a better term.

This study may lead us towards the old argument of Wollaston (Daubeny on the atomic theory, 2nd. edition, Oxford, 1850 p. 125) that if the constitution of the gases is atomic there should be a limit to our atmosphere, a sentiment in general accord with our author's 2nd. chapter (p.8) in which we find a short but lucid account of Sir J. J. Thomson's method of recording the single impact of an atomic mass on a photographic plate and plotting out dotted lines or curves by sequent impacts. This method of research opens out new vistas (p. 8 to 14) as to estimating masses, and by improvements due to Aston certain atomic masses have been estimated with a conjectural accuracy of about one part in a thousand.

The details of this surprising progress in the study of the nature of matter are lucidly, sequently, and exactly indicated in Mr. Loring's remarkable book, but we may perhaps attempt to give our readers a faint concept of the principles which underlie the means by which the relative weights or masses of individual atoms or molecules may be estimated, even in a mixture containing masses of varying magnitude; and it is conceivable that developments of this method may ultimately lead to the automatic plotting out in graphic form of all the relative weight of the atomic masses and also the relative proportions. In this spirit we may dream until we imagine all the elements automatically recording or charting their own characteristics in number, measure, weight, and relative proportion.

Imagine a high attenuation in a vacuum apparatus and atomic masses flying off in random directions, while a long narrow tube serves to sort out such particles as fly in one direction. By virtue of the electric charge or associate electron, each particle, atom or *quasi*-atom may, under proper conditions, imprint a minute developable spot on a photographic plate: this making it possible to obtain a time record as to the incidence of each mass as it impinges upon a traversing sensitive surface. Let us now suppose a stream or sequence of individual atoms emerging from the outer end of the long narrow tube, and on this stream an electro-magnetic field or other like deflecting agency is brought into play. It is obvious that the constituent atoms of the stream may thus be sorted out according to their responsivity to the deflecting influence. Appropriate arrangements of deflecting agency

and sensitive plate may so order things that similarly deflected atoms form curved tracks on the plate and from these tracks rather full data may be calculated, especially when the reponsivity to the deflecting agency is a function of mass. A remarkable vista of ultimate progress thus suggests itself, in the shape of a photographic plate covered with dotted curves each being produced by particles of like mass. Towards this aim much has been realised, as will be evident to any one who reads Mr. Loring's work.

One immediate result, as recorded in the second chapter, is that good reason is found for the conjecture that some of *our* "elements" ("*quoad nos* Elements," to use the term adopted by Dr. Daubeny to avoid such verbal solecisms as compound atom, or compound element, see p 428 of his 2nd. edition of 1850, mentioned above) are compound in the sense of being composed of constituents which differ in atomic weight or mass by whole numbers, and that it is the mixture of these whole number isotopes (Soddy uses the term iso-tope as indicating that they occupy the same field or locality in the periodic system) which gives rise to some, many, or perhaps all of the departures from Prout's law of whole numbers: hydrogen, however, appears to stand isolated in this respect.

It is impossible even to hint at all of Mr. Loring's many co-ordinated matters, but we may mention dicta as to the nature of light-emission, the Zeeman effect, and inter-atomic spaces being apparently related to the planetary distances; also we may mention one figure or parable given by Mr. Loring to aid the imagination in forming a concept of the starry heavens in miniature. Our author tells us (p.82) to suppose the whole starry heavens as seen by man to be proportionally reduced until contained in an ordinary room. and then the individual units would be as invisible as are the molecules in air.

The octet theory which follows is based on an attempt to apply the recognised laws of electrical attraction and repulsion to the study of the stable equilibrium of particles, and the conclusion is that atoms generally possess a property that may be more or less indicated by the similitude "cubic symmetry," and it may be noticed that the graphic formula of pyrophosphoric acid as represented on page 109, according to the octet theory, rather recalls the graphic notation of Crum Brown, as adopted by Frankland in his lecture notes for chemical students, London, 1866: but the figurative units of Crum Brown are spherical, while those of the octet theory are cubical.

If reference is made to Dr. Daubeny's work mentioned above, it will be seen that the atomic theories of Leucippus, and also his cosmogony (p.12) have an interesting parity with what is stated by Mr. Loring as to atomic energies; also distances in relation to the heavenly bodies and their orbital conditions; while in the Pythagorean doctrine of numbers (p.29) there is some germ of the octet idea: indeed this octet view runs more or less through the writings of the atomists of ancient times. Dr. Daubeny in the work which we mention, gives a very good summary of ancient views on atomism; mainly Indian, Greek, and Roman. As the many merits of Mr. Loring's book make it probable that in a sequence of editions it will become the standard work on atomic theories, it may be well for the author to re-consider and revise his account (p.1) of the views said to be attributed to Democritus: possibly in some Greek play intended to burlesque the views of the atomists who in Athens were popularly held to be heterodox by reason of their teachings as to the revolutions of the heavenly bodies, and their rejection of the anthropomorphic deities of Greek mythology.

Dr. Daubeny (p 462 of his 1850 edition) gives high praise to Democritus as one who set the example of questioning nature by experiment and refers to Bacon's eulogium of Democritus with respect to his profound acquaintance with physical Science, and mention is made of the way he was "ridiculed by the vulgar," e.g. in Athens. In short, as present-day investigations have made the atomic theory almost a reality, it is expedient that future editions and other works on the subject should be prefaced by connected notes on the views held in ancient times. Dr. Daubeny's book represents good work and scholarship up to the date of its publication, and something has been done since by French chemists. One great difficulty is to attach correct meanings to the terms used in the older writings, especially those of Athens in the period of Pericles and subsequently

GENERAL NOTES

CHEESE PRODUCTION IN GREECE.—According to a report by the U.S. Vice-Consul at Athens, the cheese production of Greece for 1920-21 is 30 per cent. less than for 1919-20 on account of lack of pasture, the winter having been mild and snowfall insufficient. The production of cheese has been: Casseri cheese, 4,252,250 pounds in 1920 and 2,962,575 pounds in 1921; macaroni cheese, 9,875,250 pounds in 1920 and 6,912,675 pounds in 1921; cheese sliced in brine, 8,464,500 pounds in 1920 and 4,937,625 pounds in 1921. This year the sale of cheese is not subject to Government regulation. Market prices per oke (1 oke=2.82 pounds) are as follows:—Macaroni cheese, wholesale, 10.40 drachmas (1 drachma=about 3½d. at present exchange), retail, 12 drachmas; casseri cheese, wholesale, 12 drachmas, retail, 13.20 drachmas; cheese sliced in brine, wholesale 7 drachmas; retail, 8 drachmas.

BRAZILIAN CENTENARY EXHIBITION.—The prospects of this exhibition, which will be held from September 7th to December 22nd, are reported to be excellent. The site offered for the British Section is, according to the "Board of Trade Journal," among the finest in the whole exhibition area, and the local arrangements are in the hands of a Committee, of which H.M. Ambassador, Sir John Tilley, is president. On the 28th December the Governor of the Federal State (Dr. Carlos Sampaio) laid the foundation stone of the central permanent pavilion, which it is intended to present to the Brazilian Government as a memorial of the occasion at the close of the exhibition. Although the present state of Brazilian exchange militates against the hope of immediate business on a large scale, British traders, it is pointed out, cannot ignore the Brazilian market, which offers special attractions in certain clearly defined lines. The Brazilian people are said to be strongly predisposed in favour of British firms and British goods. The British capital invested in the country, exclusive of that invested in banks, shipping and telegraphs, aggregates to no less than £250,000,000 sterling.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, FEBRUARY 6 .. Health, People's League of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Dr. B. Hart, "Primitive Instinct."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Dr. A. T. Schofield, "Difficulties of Evolution."

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. T. J. Gueritte, Presidential Address.

Chemical Industry, Society of, at the Chemical Society, Burlington House, W., 8 p.m.

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Geographical Society, Æolian Hall, New Bond Street, W., 8.30 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. President's Address to Students, and presentation of prizes.

Royal Institution, Albemarle Street, W., 5 p.m. General Meeting.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Mr. J. Joseph, "Some Practical Applications of the Thermionic Valve."

TUESDAY, FEBRUARY 7 .. Royal Institution, Albemarle Street, W., 3 p.m. Prof. H. H. Turner, "Variable Stars." (Lecture II.)

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Col. T. C. Hodson, "The Primitive Culture of India." (Lecture III.)

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. The Secretary, Report on the Additions made to the Society's Menagerie during the months of November and December, 1921. 2. Mr. A. H. Evans, "Some Deductions from a Set of Cuckoo's Eggs taken near Cambridge, and now exhibited." 3. Lord Clifford of Chudleigh, "On *Nototherium Mitchelli.*" 4. Miss L. E. Cheesman, (*a*) "Sense-organs of the Fresh-water Crab *Cardisoma armatum.*" (*b*) "Position and Function of the Syphon in the Amphibious Mollusc *Ampullaria Vermiformis.*" 5. Mr. C. W. Hobley, "The Fauna of East Africa and its Future." 6. Dr. J. Stephenson "Contribution to the Morphology, Classification, and Zoogeography of Indian Oligochæta: IV. On the diffuse Production of Sexual Cells in a Species of *Chætogaster* (Fam. Naididæ). V. On *Drawida japonica* (Michlsn.), a Contribution to the Anatomy of the Moniligastridæ. VI. On the Relationship of the Genera of Moniligastridæ; with some Considerations on the Origin of Terrestrial Oligochæta.

Marine Engineers, Institute of, 85, The Minories, Tower Hill, E., 6.30 p.m. Mr. R. W. Robinson, "Combined Internal Combustion and Compressed Air Engine."

Alpine Club, 23, Savile Row, W., 8.30 p.m. Mr. T. H. Somerville, "Five Weeks of Good Weather in 1921."

Electrical Engineers, Institution of (N. Western Section), 17, Albert Square, Manchester, 7 p.m. Messrs. L. J. Romero and J. B. Palmer, "The Interconnection of A. C. Power Stations."

WEDNESDAY, FEBRUARY 8 .. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m.

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Professorial Lecture.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. W. Doderet, "Racial Types in the Bombay Presidency."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. L. Cobbett, "The Role of the Three Types of Tubercle Bacilli in Human and Animal Tuberculosis."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Prof A. W. Kirkaldy, "Industrial Unrest: Does it make for Progress?"

Automobile Engineers, Institution of, at the Institutions for Mechanical Engineers, Storey Gate, S.W., 8 p.m. Mr. E. L. Bass, "Engine Lubrication."

THURSDAY, FEBRUARY 9 .. Royal Institution, Albemarle Street, W., 3 p.m. Sir Napier Shaw, "Droughts and Floods." (Lecture II.)

Historical Society, 22, Russell Square, W.C., 5 p.m. Anniversary Meeting. Address by the President, the Hon. J. W. Fortescue.

Central Asian Society, at the Royal United Service Institution, Whitehall, 5 p.m.

Optical Society, at the Imperial College of Science, South Kensington, S.W., 7.30 p.m. Annual General Meeting.

Metals, Institute of, Technical Institute, Jewry Street, E.C., 8 p.m. Mr. R. T. Rolfe, "Gun Metal."

Antiquaries, Society of, Burlington House, W., 8.30 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Chemical Society, Burlington House, W., 8 p.m. Sir Ernest Rutherford, "Artificial Disintegration of Elements."

Mechanical Engineers, Institution of (Midland branch), The University, Birmingham, 7 p.m. Mr. W. R. Parsonage, "Aircraft Tubes."

FRIDAY, FEBRUARY 10 .. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Sir Joseph Broadbank, "Progress in the Port of London."

Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7 p.m. Lecture by Mr. G. P. Gaskell.

Royal Institution, Albemarle Street, W., 9 p.m. Prof. W. D. Halliburton, "The Teeth of the Nation."

Electrical Engineers, Institution of (Irish Centre), at the Royal College of Science, Dublin, 8 p.m. Mr. R. D. Archibald, "A Method of Regulating the Voltages on two Sides of a Three Wire C. C. System, Equalised by Static Balancers."

Malacological Society, at the Linnean Society, Burlington House, W., 8 p.m.

Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, FEBRUARY 11 .. Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. de Selincourt, "Humorists of the Seventeenth Century." (Lecture II.)

Teachers in Technical Institutes, Association of, Technical School, Bolton, Lancashire, 2.30 p.m. Mr. A. E. G. Brookes, "Design, Colour and Structure of Textile Fabrics."

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 205.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICES.

NEXT WEEK.

WEDNESDAY, FEBRUARY 15th, at 8 p.m. (Ordinary Meeting.) CLOUDESLEY BRERETON, M.A., Divisional Inspector to the London County Council (Modern Languages), "The Necessity of Speech Training, and the Need of a National Conservatoire." SIR HENRY NEWBOLT, C.H., D.Litt., LL.D., Chairman of the Departmental Committee on the Teaching of English, in the chair.

CANTOR LECTURE.

On Monday evening, February 6th, Mr. C. Ainsworth Mitchell, M.A., F.I.C., delivered the third and final lecture of his course on "Inks."

On the motion of Mr. C. T. Courtney Lewis, a vote of thanks was accorded to Mr. Mitchell for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 1st, 1922; SIR CECIL HARCOURT SMITH, C.V.O., LL.D., Director and Secretary, Victoria and Albert Museum, in the chair.

The following candidates were proposed for election as Fellows of the Society:-

Forrest, L. R. W., London.
Gomat, C. S. Ganapathier, Madras, India.
Soames, Mrs. Geraldine, Rugby

The following candidates were balloted for and duly elected Fellows of the Society:-

Ainsworth, E., London.
Anderson, Roy King, Bassein, Lower Burma.
Ashworth, Sidney Herbert, A.I.Mech.E., V.D., Naihati, Bengal, India.
Bando, S. N., B.Sc., Calcutta, India.
Brooks, Milton, Calcutta, India.
Chak, Pandit Sangam Lal, Lucknow, India.
Choudhari, Dhanji Garbad, London
Desai, Gapaldas Viharidas, Gujerat, India.
Douglas, Frederick William, B.A.Sc., A.M.E.I.C., New York City, U.S.A.
Hall, Wilfred, B.Sc., Tynemouth
Murphy, Walter P., Chicago, U.S.A.
Nelson, Frank, Bombay, India.
Nichols, Ronald Herbert, Kulti, Bengal, India.
Oughton, Ernest, O.B.E., M.Inst.M.M., Hindubagh, Baluchistan, India.
Piggott, Leonard Charles, F.R.G.S., Buxton, Nr. Norwich.
Pratley, Philip Louis, M.Inst.C.E., Quebec, Canada.
Sherman, Major Norman Clarence, Esquimalt, B.C., Canada
Soundy, L. H., London
Tait, Louis Benjamin, Rangoon, Burma
Taylor, S. H., Cawnpore, India.
Thaker, Narmadashanker Ganpatram, Ahmedabad, India
Vernon, George Shirra Gibb, Calcutta, India.
Walker, Herbert Wilson, Seascale, Cumberland.
Warburton, Walter Granville, O.B.E., J.P., Bombay, India.
Wicksteed, Henry K., B.A.Sc., M.E.I.C., Toronto, Canada
Yabsley, Percy, Aylesford, Kent

A paper on "Surface Printing by Rollers in the Cotton Industry; a comparison with other Processes of Printing Patterns for Cretonne, Dress Material, Wallpaper, etc.," was read by MR. ARTHUR WILCOCK.

The paper and discussion will be published in the *Journal* of February 24th.

DOMINIONS AND COLONIES SECTION.

TUESDAY, FEBRUARY 7th, 1922; LORD CLINTON, Forestry Commissioner, in the chair.

A paper on "The Timbers of British Columbia" was read by MR. WILLIAM TURNBULL, Timber Commissioner for the Government of British Columbia.

The paper and discussion will be printed in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

WEDNESDAY, JANUARY 25TH, 1922.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

THE CHAIRMAN, in introducing Mr. Howard Edmunds, the author of the paper to be read that evening, said he wished to draw attention to the fact that an original invention was about to be described by its inventor. It was always a great privilege to hear such things described by the actual inventor, and in the present case the process which was the subject of the paper was entirely the invention of Mr Howard Edmunds.

The paper read was:—

PHOTO-SCULPTURE.

By HOWARD M. EDMUNDS.

Photo-sculpture is a process by which, through the agency of photography, we are able to produce carved replicas in relief, or in the round, of any solid object.

The carrying out of this process has been helped very much by recent advances in plates, and by the highly accurate photographic lenses now available. The subject is so much in its infancy that criticism of the results obtained should be tempered by reflection on the difficulties of any new development of this kind. The basic theory may be correct; but in carrying it out much has to be learned by experience.

The broad principle upon which the method to be described this evening depends, is as follows. By projecting a system of markings successively upon a plane surface and upon an irregular solid, one can register photographically the change in form which the markings undergo due to the substitution of the solid for the plane surface.

To make this clear we must first consider the case of photographing an image upon a plane surface. This is what occurs when a picture or print or map is photographed. In general such pictures are photographed by a camera with its lens facing the middle of the picture, and the plate parallel to the plane of the picture. When this is done, if a well-corrected lens is employed, a facsimile of the form of the picture is obtained, differing only in scale from the original. This also happens if the lens of the camera does not face the middle of the picture, provided the axis of the lens is still at right

PORTRAIT BAS RELIEF FROM LIFE CARVED IN IVORY BY EDMUND'S PHOTO-SCULPTURE PROCESS.
WORK UNTOUCHED AFTER LEAVING CARVING MACHINE

angles to the plane of the picture. This fact is made use of in Photo-sculpture. I would also like to make it clear at this point that the camera and plate may be turned at an angle to the picture, when a foreshortened result will be obtained; and, for example, the sides of a rectangular picture will appear to converge. This second photograph may be converted to the undistorted form by enlarging it with the easel inclined suitably, so as to correct the distortion of the original negative. This point, also, is made use of in the process of Photo-sculpture.

A number of types of markings are suitable for carrying out this process; but in the description which follows I will keep to the one which has been used in the experiments up to the present; that is, a spiral line of the same form as the groove in a gramophone record. I also propose to use a grid, of parallel straight lines.

We must now consider what the effect will be of replacing a plane surface by a solid object. First it is clear that, viewed from any position (except that of the projector lens) the lines on the solid object will be displaced from the position they occupied on the plane surface. In order that these displacements may follow a definite law which can be taken advantage of in a carving machine, the camera must be placed with its lens in the nodal plane of the projector lens. When this is done, all points on the lines of the undistorted figure move in parallel lines.

I do not want to labour the mathematical proof of this, as it is somewhat technical; but it is borne out by the faithfulness of the result to the form of the original solid object.

Having secured a photograph in which the lines are clearly visible as focussed upon the face of the sitter, the next step is to prepare what I have called a guide plate, to be used in the carving machine. If the camera is placed with its lens axis parallel to the projector lens axis, and the plate of course normal to this axis, then the negative will be in the correct form for use as a guide-plate. It is often convenient to place the camera with its lens pointing straight at the object, so as to use the axial zone of the lens, which is apt to be better corrected than the marginal one. When this is done, the resulting photographs must be enlarged, and corrected in such a way that a photograph taken of the spiral projected on a plane surface is undistorted, and of exactly the right size. This is the method I have adopted up to now in making the carvings that are shown here to-night. The enlargement is made on opal glass, so that there shall be no change in dimension owing to the process of development, as would be the case if bromide paper were employed

Having secured a guide-plate, the next step is to use this in a suitable machine for producing the carving. It is important to bear in mind that the guide-plate consists of a plane surface, with a series of lines clearly shown upon it. These lines are not a true spiral; but their displacements from the true spiral form are all parallel, and of an amount proportional to the depth of the object at each particular point. The straight line shown on the guide-plates indicates the direction of displacement. The guide-plate is fixed to an iron carrier in the machine; and this has a compound movement imparted to it, giving it a spiral movement; but, at the same time, any line moves in a path so that it is always parallel to its former position. In other words every point on the plate describes the same spiral. The model I have here will make this clear.

A drill and a microscope are mounted on a steel rod, free to move in the direction of its length, but constrained from any other movement. The guide-plate is fixed to the plate carrier, so that the direction of the displacement line is parallel to the microscope movement. A headstock is fixed with its axis parallel to the microscope and drill movement, and is given both rotation and side travel, so that the drill carves out a spiral form on the material to be carved, which is fixed to the headstock. It only remains to follow the lines on the guide-plate with the cross-hairs of the microscope, and the rapidly rotating drill carves out furrows of varying depth in the carving block, thus producing the relief carvings.

The relative distances of camera and projector to the projector and the object photographed determines the degree of relief. In practice I have found from one fifth to one-quarter the most suitable; but that will doubtless be modified by further experience.

Work has been done in ivory, alabaster, and wood; and the number of lines per inch has been 20, 40 and 100. The fineness of modelling obtained by carving 100 lines per inch is such that the grooves in the carving are scarcely noticeable; just as in a half-tone reproduction, the lines of the screen are not noticed, and the reproduction appears like any ordinary photograph, although in reality it is a series of dots of varying size and form.

The amount of labour necessary to complete one of these carvings can be judged by the time taken. One with about 200 lines requires about eight hours. The work is very interesting, as the results can be inspected between the cuts, and the progress noted. Close attention is necessary to avoid a false cut; and hours of patient work may be spoiled by a single mistake; but with practice the chance of this is almost entirely eliminated.

I have some diffidence in touching upon the probable scope of this invention; but making portraits in relief would seem to be a promising field. The great accuracy of which the process is susceptible will render it possible to reproduce existing works of sculpture on any scale and in any degree of relief; and no doubt this could be made use of for decorative purposes. Just as photography has made possible the enjoyment of the great paintings of the world to a much greater number of people, so it is perhaps not impossible that the camera may do useful service in reproducing the form of the great masterpieces of sculpture.

(The paper was illustrated by lantern slides and a cinematograph film).

DISCUSSION.

THE CHAIRMAN (Mr. Alan A. Campbell Swinton F.R.S.), in opening the discussion, said he was sure the author had made very plain to the audience the manner in which the invention worked. Personally he had had the opportunity of visiting the author's home near Brighton and had seen the actual machinery in operation. The machinery was very heavy and therefore it was not possible to bring it to the meeting that evening, but in a way the cinematograph made the process clearer than it would be to anyone seeing the actual machine at work, because the cinematograph enlarged it on the screen. As far as he knew, the invention was an entirely new one; he did not think anything of the kind had ever been suggested before. The method of registering variations in depth by deviations from either a straight line or a spiral was a most ingenious device. It seemed to him that there must be many applications for the process; tombstones seemed the natural thing to think of first, but he supposed it could be adapted also to the making of such things as medals. He took it that the machine could be reversed so as to make a concave engraving instead of a convex one, and by that means it would be possible to make dies for the pressing of medals. Then of course the invention provided a wonderful method of reproducing sculpture, and that could be done on any scale. The scale could be varied either in the photographic part of the process or by merely altering the gear wheels in the reproducer. The invention seemed to him to have endless possibilities. He was not an artist but looked at such things entirely from the scientific point of view, and he had been recently taken to task by an eminent Academician who said that such things were quite wrong—that they were not art. His reply had been that no one claimed that they were art. If it was agreed that there must be no reproductions of people except through the medium of the artist, ordinary photography would also have to be abandoned, but there was no doubt that photography had come to stay and had very useful functions, and he felt that the author's latest development of photography had also great possibilities and many uses.

SIR FREDERIC KENYON, K.C.B., D.Litt., LL.D., F.B.A., (Director and Principal Librarian, British Museum) said he was neither a sculptor nor an artist, and the application of the author's invention which interested him most was one to which the Chairman had just referred, namely, the making of replicas of ancient sculpture and especially replicas of a smaller size. Reproductions of ancient sculpture could of course be obtained by means of casts, but it seemed to him that there might be a use for reduced size replicas, which one could be certain were not done merely by the eye but were mechanically accurate and preserved the original proportions. He would like to know whether the author had tried that application of the process, because in that way replicas might be obtained which would be useful in art schools and would also be valuable as ornaments in private houses where there was not sufficient room for full size reproductions. As a rule one mistrusted the small reproductions of statuary or reliefs that were seen in shops, because their accuracy could not be relied upon. If he understood the author's invention aright, it would give a perfectly accurate reproduction of the original, and he could see no objection to a process of that kind. If it was used in the case of a living person it might not be as good as the work of a great artist, because it would only bear the same relation to a great artist's bust or bas-relief as a good photograph bore to the work of a great painter, but in reproducing a work of art such as an ancient bas-relief all that was required was accuracy and fidelity, which he thought the author's invention would give. He would like to know whether the process was applicable to marble, or whether marble would be too hard for the purpose. If it was applicable to that substance, reproductions could be obtained of the frieze of the Parthenon, on any scale desired and in the original material, which would give what plaster casts could not give, namely, the qualities of the surface. If that was possible, it seemed to him that at any rate in that direction there would be very valuable applications for the author's invention.

MR. CECIL THOMAS said the invention was a most interesting and remarkable one and the author was to be congratulated on devising such a very ingenious machine, but it was the use of that machine with which he, in common with his brother artists, was more concerned. Did it make for progress or the reverse? He was sorry to say that in his opinion it made for the reverse, because he could not see that any advantage was to be gained by producing portraits, or, as a matter of fact, any work of art, mechanically from life. The quality that the touch of the artist gave was bound to be lost. If he might criticise the illustrations the author had shown, he would take one detail, the ear. In none of the reliefs shown had the ear the emphasis of life. The ear was an extremely difficult thing to model, and mechanically it was of course still more difficult to reproduce. Even in the Janvier machine which reproduced artists' models the details were sometimes lost, and that machine worked about 300 lines to the inch. The point about an automatic or mechanical work of art was that there could not be any quality or touch that emphasised character and that made a real work of art what it was—there could not be any expression in it. As the author said, it took eight hours to produce a relief portrait by his machine and as any competent artist could do that same portrait in from one to three hours, he failed to see what

was the advantage of the author's invention, apart from the advantage to the sitter. It was very unpleasant for a man to have to sit for three hours and it would be most delightful for him to be able to go to the nearest photographer and sit for two seconds while he was photographed for a relief portrait. So far as the result was concerned, the average member of the public was not particularly interested in the quality of the work. It was a remarkable fact that, when an artist produced a portrait with which he was dissatisfied and which he felt was not at all his best work, the average person would say it was charming—so long as it had some resemblance to the original, people were quite satisfied. But it was the quality of the work which all the movements associated with art were concerned to foster. The Arts and Crafts Society, the Art Workers' Guild and all such Societies tried to lift the arts and make them a more emphatic means of expression of the artist's mind. Mechanical devices, unless they were the servant of the artist, could not make for progress; they could only make a step backwards Scientifically it was progress; artistically it was the reverse. The Chairman had referred to photography as being an art, but it was only an art when it was in the hands of an artist, and very few artists cared to give their time to mechanical means of reproducing what was in front of them when they had the ability to do it with their hands and to express their minds He was afraid he had not been very optimistic in what he had said, but he viewed mechanical means of reproduction that took away the artist's control as a step in the wrong direction

MR. ALLAN G. WYON said he wished to support what Mr. Cecil Thomas had just said. Whilst he greatly admired the author's invention as a piece of machinery and as a very remarkable achievement of its kind, it could not in the nature of the case give that which only the artist could give. It might be said that it did not pretend to do so, but it was important that the artist should emphasise that point. The photograph at its best could not give what the portrait painter could give. The difference between the work of an artist and the work of a machine was that the artist exercised a power of selection: he chose certain things to emphasise and certain things to make insignificant. For instance, the ear had been referred to by Mr. Cecil Thomas, and a sculptor in modelling a face in relief from the side view often made the ear inconspicuous, lest it should take to itself too much emphasis and importance. He mentioned that as a single instance, but that system of selection was what constituted a work of art. From every other point of view he had a great admiration for the author's machine and for the work he had shown that evening.

MR. H. LYON THOMSON said he had been deeply interested in the paper, the process described therein being, as the Chairman had pointed out, an entirely fresh departure from anything of the kind that had been previously attempted. Early in the sixties there was a process—or what purported to be a process—of photo-sculpture in the round, in which a building was erected with 24 cameras placed at equal distances and photographs were taken from each point of view, the photographs being then projected on a screen and, by means of a pentagraph, reduced. It was afterwards ascertained, however, that a skilful artist was employed on the work, only the apparatus being shown to the public. He thought the author's invention led one into an entirely new train of thought, and it was difficult to see the ultimate results that might be achieved by a continued application of the system. He would like to ask the author whether he had made any attempt to produce the spiral in relief by means of any gelatine process, so that the machine would automatically follow the lines without the intervention of the human hand. With regard to Sir Frederick Kenyon's remarks about reproducing classical works of art on a small scale, that did not present any difficulty at the present time, because the ordinary reducing machine would do that from a mechanical point of view with perfect accuracy. Such machines as were employed on medals would also of course, either from a cast or from a counter-cast, engrave on steel, by means of the diamond point, a die either in reverse or in relief.

MR J. TAYLER FOOT said he had done a considerable amount of work with the ordinary reproducing machine and had made the models necessary for that machine in wax and plaster He was much interested in the author's invention, and thought that the method it provided of making a rough model for a portrait medal would be of great help to him at the present time. He could then finish it by hand and thus make it into a work of art.

In reply to questions by COLONEL C. M. SIMPSON, D.S.O., R.F.A, MR. EDMUNDS said that an electric motor was used to work the machine. It did not work at a constant rate, there being a speed variation which provided for two speeds being used.

MR. G. ELLIOT ANSTRUTHER said that, speaking as a man who was neither an artist nor a scientist, he thought those present that evening had been witnessing the exposition, by the inventor himself, of a remarkable achievement of ingenuity for which he claimed no more than he had been able to prove. The author had demonstrated that, by the application of certain mechanical principles in a new and original

way, he had secured the translation of something on a plane surface into something on a convex surface, and that, as an invention in a state of infancy, his machine had attained an obviously remarkably high degree of fidelity. Without wishing to cast any aspersions upon any of the remarks made by previous speakers, he personally felt that, in suggesting a kind of comparison between what was to be expected from the artist and what was to be expected from the mechanician, it must be borne in mind that the author had not put forward his invention otherwise than as a mechanical device There was a danger, in dealing with fidelity, of imagining that there was a certain infallibility about the portrait painter and that he was going to exhibit a higher degree of fidelity to the original than the author's machine would do. It ought not to be assumed that because the means of production were a man's hand, brushes and palette the result would necessarily be a more faithful representation of the original than would be produced by a photographic process or by the invention which the author had described. He thought everyone present had been intensely interested in the lucid and modest exposition the author had given of an invention which, as the Chairman had said, was one of very remarkable ingenuity and an unknown quantity in regard to future developments. He was sure that, in saying he had greatly enjoyed that exposition, he was expressing the feelings of everyone present.

THE CHAIRMAN (Mr. Alan A Campbell Swinton, F.R.S.) said he had been very interested in the remarks made by Sir Frederick Kenyon. The author had brought to the meeting some actual reproductions of classical statuary on a small scale which he thought showed quite clearly that the process was adapted to the reproduction of works of art. With reference to the question of art he might mention an incident that had occurred a few days ago. A member of the Council of the Society, Sir Charles Parsons, had had his portrait painted by Sir William Orpen and it was desired to have that portrait reproduced. He asked Sir William Orpen whether it would be best to have a mezzotint made of it, but Sir William's advice was to have a photogravure made. Photogravure was a purely mechanical process, but Sir William Orpen recommended that in preference to making a mezzotint, which was not a purely mechanical process. It would therefore be seen that there was some difference of opinion in the artistic world on the subject of mechanical processes

MR. HOWARD B. EDMUNDS, in replying to the discussion, said the Chairman had already answered Sir Frederick Kenyon's question about reproducing classical works of art by means of photo sculpture. One advantage that that process possessed was that it could reproduce a work of art in a different degree of relief. The Janvier machine had been referred to by Mr. Cecil Thomas. That was a very delicate and beautiful machine for reproducing the works of an artist on a smaller scale but in the same degree of relief. In touching on the artistic side he was absolutely out of his depth, and he gave place to the two gentlemen who had criticised his invention from that point of view, but he did not claim for it anything more than that it could reproduce the form of the original object. Mr. Cecil Thomas had said that photography became an art in the hands of an artist, and it was not impossible that the same might apply to his invention in the future and that it might produce results which would not be unpleasing to the artist

On the motion of the Chairman, a hearty vote of thanks was accorded to Mr Edmunds for his interesting paper and demonstration, and the meeting then terminated

MR. HENRY EDMUNDS, M.Inst C E, M.I.E.E, writes :—

Though present at the Royal Society of Arts when my son read his paper on Photo-Sculpture, I did not take part in the discussion: but I should now like to add my views. Faraday at the Royal Institution in the last century demonstrated his classic discovery that an electric spark could be produced at the ends of an insulated wire surrounding a permanent magnet when the armature or keeper was detached from the magnet. He was asked what was the use of it? He replied "What is the use of a baby." That discovery was the forerunner of our present systems of electric generation by dynamo-electric machinery, and the transmission of energy for lighting, heating, and power In 1877 I was present at Edison's workshop in Menlo Park (New Jersey), and witnessed the first recording and reproduction of human speech by the means of a simple diaphragm equipped with a drawing pin for a stylus, and a sheet of tinfoil mounted on a grooved brass cylinder turned by hand. This was indeed an epoch-making event! It was considered wonderful at the time; but of no commercial value. It was over ten years before Bell, Tainter, Berliner, and Edison—all pioneers—could produce a machine that could talk—and earn dividends. In 1888 I read a paper before this Society on talking machines, which were then still in their infancy. I may appropriately ask "What is the value of those infants to-day?"

There are modern Herods who do not hesitate to seek the young child's life: to strangle it in its infancy: lest it should grow up and become a menace to existing interests. There is a parallel between Phonographs and Photo-Sculpture. The one records and reproduces sound: the other records and reproduces form.

It has been absolutely proved, beyond doubt, that the recording of "form" is a complete success, optically and photographically; and the interpretation of the record by mechanical means is also most encouraging. Instead of ten years elapsing, as with the Phonograph, before a satisfactory reproduction of sound was effected, in less than ten months we have succeeded by means of Photo-Sculpture in giving faithful examples of the reproduction of "form" in various media— wood, stone, ivory, and metal. The development and improvement in each successive instance has been most marked; and demonstrates that only experience is necessary to arrive at complete results.

In reply to the questions as to what artistic use, and what commercial value, there may be in this invention, I would say, from my own observation, to the sculptor, that he can have an exact record of the form of his subject produced photographically in ten seconds, without any inconvenience to the sitter, who may be a busy man and unable to spare time for a careful modelling in clay, and later retouching to perfect the likeness It is true that one may get a "sculpturesque" impression—as in nature we meet with profile rocks giving at a certain angle a vivid suggestion of some notability. varying according to the imagination of the observer: but such tours de force are seldom satisfactory, even at the hands of an artistic genius With this present process it is no longer necessary to prepare a mask in plaster—objectionable to the living: and a caricature of the dead. The photographic record can give the living smile or frown, or any other characteristic expression of the subject; and thus give the impression of actual life. The finished work can be upon any required scale, magnified or reduced, and yet preserve the exact proportions of the original; and it is not in soft wax, or clay, but in imperishable marble, and eternal bronze.

Knowing that all these things can be done, the commercial success of the invention is assured. Such success will come slowly or quickly, according to the financial support it receives— for all new processes need nourishment in infancy.

It has been objected that Photo-Sculpture is not creative: that it cannot rival the artist, who may by his skill and genius evolve a form of charm and beauty according to his own ideal, but the function of Photo-Sculpture is to reproduce copies of these ideals, preserving every touch and detail of the original, on any scale, large or small—a feat which can seldom or never be obtained by an ordinary workman, however painstaking and clever he may be An additional application is the presentation of life-like portraits of the individual, which can be executed at any time after the "record" has been obtained. Futhermore, Photo-Sculpture may be used to multiply works of beauty, classic or modern, giving a wider field for the talent of the artist, educating the artistic sensibility of the public; and increasing the human enjoyment of the Fine Arts. In the art of architecture there is an unlimited field that has not yet been touched. Photo Sculpture is thus the handmaid, not the rival of the sculptor They both will live and inspire one another.

The Chairman referred to grave-stones, as among the possible uses of the system. When I was last in Genoa, and visited the famous and beautiful Campo Santo, I saw hundreds of memorials in marble which had merely had ordinary photographs let into the stone, and, although protected by glass, many of these were faded and useless. Had Photo Sculpture been invented before the Great war, fifty per cent of the war portraits would have been taken by this process, and thus friends and relatives would have had them as "records" for future memorial. In France and Belgium to-day, we and generations to come might have visualised the heroes who gave their lives for King and Country, instead of an undistinctive name, or a number

When the paper was read, the cinematograph pictures did much to illustrate the system, and help the audience to understand the process, which might have been more difficult to grasp from only the spoken word of the lecturer Briefly, one may describe it as follows— In a dark room light from a magic-lantern is projected on to the face of the subject, through a screen of glass upon which is a series of lines in a spiral form— something like a gramophone record. These lines, falling on a plane surface, would show as a uniform spiral: but when projected on to the human face, for example they become irregular and distorted A photographic camera at the same time receives on its sensitive plate, the object before it, with all its distorted lines This plate is fixed and developed, thus furnishing the "record" which is afterwards employed in the carving machine, enabling the operator, by carefully following these lines, to control a revolving cutter, or drill, which effects a cut of varying depth in the material upon which it is acting; and thus produces a solid copy in the three dimensions—length, breadth, and height—of the subject upon which the lantern has thrown its rays.

NOTES ON BOOKS.

Cane Sugar Revised Edition By Noël Deerr London: Norman Rodger 1921. 42s. net.

We have here a practical text book adapted to the needs of the planter or planter-manufacturer, and one which deals with operations and conditions incidental to cane sugar plantations, as also to works associated with the plantations. In other words, the present volume fully and satisfactorily covers minute details from the preparation of the soil to the

output of plantation white sugar, and such incidentals as rum and molasses.

Mr. Noel Deerr's book embodies 644 + VIII. large octavo pages, 29 inset plates of which many are admirably executed in colours, so as to illustrate insect pests (plate XVI. opposite p. 144) or the tints and characteristics of the standard varieties of cane. (Plates I to X.) Besides the plates, there are 356 engravings in the text.

That the author is an enthusiast, and that every detail relating to his subject is a source of delight to him is obvious almost at the first, and the work has all the merits that enthusiasm and painstaking can impart--clear, concise and unmistakeable wording, full references to other books and authorities, good indices and that practical stamp which comes of a career devoted to this subject.

The sugar cane region is carefully traced, in reference to the varieties and their economic value or characteristics; the range in habitat of this remarkable giant perennial grass, which covers the warmer regions all round the earth, where abundant water supply is available, although botanists consider Eastern Asia to be its original home. As an extreme it may be mentioned that at the Great Exhibition of 1851, there was an exhibit of sugar from canes grown in Surrey. In size the varieties show wide range, from the small reed like canes grown by the Ryots of British India to the elephant cane of Cochin China.

As a part of his study of the vital functions of the cane in special relation to pests, climate and surroundings Mr. Deerr shows (p. 5) a highly instructive section of the leaf in condition almost as living; the sudden fixing or killing of the tissues with osmic acid vapour while the leaf was on the plant, having secured a condition perhaps unobtainable by other means. The leaf is the essentially vital organ of the plant, and the 37 marked regions are, together with the text, remarkably instructive as to the vital functions, life history and the attacks of disease. Practical botanists will study this section with interest.

Natural and artificial fertilization is considered at great length, and also the questions incidental to inheritance in seedlings. In Hawaii the seeds are sown in boxes, the mould being a rich vegetable product obtained from the neighbouring forest. This mould is sterilised by boiling to kill seeds of other grasses. In India the method is somewhat different, but in all cases, great care appears to be required at this stage, and when about two months old, the seedlings are ready for transplanting to flower pots or wicker baskets, but it is after planting out in the open field that the process of selection begins.

It thus becomes apparent that the culture of the cane, like the extraction of the sugar, is a highly delicate matter, but we have not even touched on many of the difficulties and delicacies of culture, as detailed by the author.

The extraction and refining are treated of in the same thorough way by Mr. Deerr, and the latest and best evaporating and centrifuging devices are fully described and figured; mainly from the point of view of restraining inversion of the crystallisable sugar and minimising partial wastage in the direction of molasses or rum. In respect of the latter product, the relation of ferments and conditions of fermentation to flavour are thoroughly considered.

The testing and analysis of sugar and sugar products are by no means neglected, and until we had glanced over the chart of optical systems in use for polarimeters (p. 483) we did not realise that they are so numerous.

The author is evidently a scholar and a student of economics, in addition to his technical qualifications, and he shows us what a technical book should be, whether as regards indexing, classification of patents, bibliographies or references, and we feel a satisfaction in receiving a book like the present volume from one of our Indian fellow-members of the British Federation: a book which should certainly be in the hands of every sugar manufacturer or merchant. It may also give lessons in system and method to all manufacturers, and, further, it should prove a delightful library book for the general reader. As an example of general interest reference may be made to Plate XXVII. and the accompanying text; these elucidating the methods adopted in Cuba for cooling water on an extensive scale.

The Handicraft Art of Weaving. By Thomas Woodhouse. Oxford Technical Manuals. London. Henry Frowde, and Hodder & Stoughton. 6*s*.

Textile Mathematics. Part I. By Thomas Woodhouse & Alexander Brand. London, Glasgow and Bombay: Blackie & Son, Ltd. 2*s*. 6*d*.

The first named book consists of 163 pages illustrated by 125 process blocks, the majority of which are of good scale, well lettered and fully explained. Others, of primitive or native weavers at work, are not so clear; indeed, some of native weavings are almost unintelligible and very small in size. Mr. Woodhouse's account of the art of weaving runs into 142 pages, and is based upon an interesting analysis of such methods as are practised by natives of the Upper Congo, by Mexicans and by Armenians, thus suggesting the large area involved in the art of weaving by hand. Modern power-driven machinery to produce textiles owes its evolution to such handicraft methods. To convert the technical instruction set forth in this book into real knowledge, supplemental practical training with appliances, etc., is

obviously necessary. The last twenty pages relate mainly to different sorts of carpet weaving and as regards the hand work, students of the subjects will find useful additional information in a small ninepenny publication at the Victoria and Albert Museum—"Notes on Carpet Knotting and Weaving," by Mr. C. E. Tattersall

Mr. Woodhouse's title to Chapter VII, "Gobelin, Ardebil and Oriental Fabrics," is rather too roving, and the chapter itself supplies but a scrappy exposition. Are not taste in the composition of patterns, and the study of standard examples, points which might have been suitably mentioned, especially in connection, for instance, with Italian 15th Century fabrics, later French, and surely Chinese, Indian and Japanese ones ?

The second of the above mentioned books embodies, as stated in its Preface, an explanation of the general principles involved in all preliminary books on mathematics The exercises at the end will undoubtedly help students to work out simple applications of these general principles to the calculation of dimensions of textiles and of machinery for their production

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PETROLEUM. By Sir Boverton Redwood, with a foreword by Sir Frederick W Black. Fourth edition. Three volumes London: Charles Griffin and Company, Ltd 1922. £5 5s.

Redwood on petroleum has long been regarded as the exemplar or pattern book of reference with respect to all matters relating to petroleum in its varied aspects, from natural gas to bitumen; it being impossible to find a logical or consistent halting place between these extremes. Notwithstanding the fact that the greater part of the new matter for the present edition was written under the stress of war times, and that the many alterations and additions involved re-setting the whole of the type, the author, who was helped by many willing friends, has given the public a new edition which adds, if possible, to the old reputation.

It is sad, however, to have to record that Sir Boverton did not live to finish his work, but his friends and helpers have completed the task.

In the new edition of Redwood's Petroleum, we have a remarkably good illustration of those features of book construction which experience has shown to be convenient for the book user The paging runs sequently from 1 to 1353 through the three volumes, and the range of pages contained in each volume is indicated on the back; thus is avoided all worry in entering two data, page and volume. Similarly, the index is unified so that one can never find oneself searching in the subject index for a name or *vice versa*. Moreover, when there is but one index, there cannot be the annoyance of finding that several of the unusual compound names have drifted over to the subject matter index. The unified index, 34 pages of small but remarkably clear printing, not only gives reference to the pages of Sir Boverton's volumes, but also to the works in the Bibliography which may be consulted with advantage: the page numbers and the Bibliography numbers being kept apart in an ingenious and satisfactory manner. The Bibliography itself is a remarkable feature, 162 pages and 8804 items all numbered so as to be readily indicated in the general index as mentioned above The maps, with petroleum areas marked in red, form an atlas of the world as far as petroleum is concerned, and in other respects they are good up-to-date maps

Redwood on Petroleum in its 1892 form is an impossible work to review satisfactorily in the usual fashion; all the expedients and wiles of the reviewer's craft failing in this exceptional instance. There is an old canon that for a review to be adulatory in the fullest sense there must be mention of some trivial fault, just to show how strictly impartial the reviewer is Even in this we are baffled, as we have not been able to find the trivial fault

It appears to us that the best possible review of an exceptionable work like that before us, would be a *brochure* of about 16 pages, so selected as to indicate the leading characteristics. Any page of the bibliography or of the index would be an exemplar, the whole being balanced and in ratio. For instance, p 1331 (index) will indicate the inclusion of such widely various subjects as "Hexadecane: Specific Heat of"; "Hong Kong: Dangerous Goods Ordinances;" "Hawking Petroleum;" "Hinks's Duplex Burner"; "Heckmann Naphtha Stills," and "Heel-ball."

A selected half dozen pages would exemplify the thoroughness in technics, ranging from minute detail, as the study of laboratory fractionating columns (p 747), and the rivet catcher on the rod of the oil well pump (p 424), to such large scale appliances as the vacuum still (p. 507) and the four other typical stills figured on the next preceding page. Other selected pages might illustrate the thoroughness of the work with respect to spray burners for light, furnace work, and power by liquid fuel A page from the section on petroleum in Great Britain (pp. 38 to 43) should serve to illustrate the completeness of the historical summaries; this one ranging from the year 1667 to the recent Government Grant for Systematic investigations and the finding of oil in the experimental boring at Hardstoft in 1919, followed by the report (September, 1920) as to the great gas blow in one of the Scottish borings

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OBITUARY.

SIR FRANCIS HENRY BARKER.—Sir Francis H. Barker, who was elected a Fellow of the Society in 1920, died at Cannes on January 28th.

He was born in 1865, and educated at Clifton College. He travelled extensively in Europe and Asia Minor, and was especially interested in Russia, being President of the British-Russia Club, and Chairman of the Executive Council of the Russo-British Chamber of Commerce. He was a director of Vickers, Limited, and of several other important companies. A knighthood was conferred on him in 1917.

TRADE OF THE BELGIAN CONGO.

The Belgian Kongo covers an area of about 910,000 square miles, comprising rich agricultural lands and mining districts. For the purpose of government, the Kongo was in 1915 divided into four Provinces—Kongo Kasai, Equateur, Orientale, and Katanga, which are in turn sub-divided into districts. The metric system of weights and measures is used, and by decree of December 28th, 1919, the Belgian franc was made the only legal money tender.

Of the three seaports of the Kongo—Matadi, Boma, and Banana—Matadi is the only one of importance. Steamers up to 8,000 tons can be docked there. From this point there is railway connection inland to Leopoldville. There are six different ways to enter the Kongo, including the Matadi route. They are as follows: Via Matadi (93 miles from the mouth of the Kongo), via Cape Town (South Africa), via Dar-es-Salaam (formerly German East Africa), via Beira (Portuguese East Africa), via Mombasa (British East Africa), and via the Nile.

For interior commerce and travel there were, on December 31st, 1917, 1,264 miles of railways in the Kongo.

Another important route for commerce is the Kongo River, which, with its branches, furnishes over 9,000 miles of navigable waterways, and presents only three impassable barriers to river steamers, the first on the lower Kongo, from Matadi to Leopoldville, and the other two on the upper Kongo, from Stanleyville, to Ponthierville and from Kindu to Kongolo. The navigable portions of the Kongo River are connected by rail with each other.

The commercial development of the Kongo, writes the Secretary to the United States Trade Commissioner at Brussels, has gone forward rapidly from the time it has been opened up to the world trade, and its development since 1900 has been particularly encouraging. The mining industries have been showing increasing returns yearly, and very successful experiments have been reported in agriculture. Coffee, cotton, and rice have already passed through the experimental stage, and are being exported in considerable quantities. Rubber has been a standard export of the Kongo, but the first cultivated plantations in the colony came of age to be profitably worked only in 1914. These new plantations should add greatly to the commercial value of Kongo rubber exports, as the rubber trade gives preference to cultivated rubber over the wild products. Other products exported from the Kongo in quantity are palm nuts, cocoa, copal, copper, diamonds, gold, ivory, palm oil, and wood.

The effect of the war on the Kongo is reflected in the greatly increased exports since 1913, due to the urgent European need for raw materials and supplies of all sorts. The following figures show the volume of certain exports from the Kongo, in the years 1913-17:—

	1913	1914	1915	1916	1917
	Tons.	Tons.	Tons.	Tons.	Tons
Rubber	3,567	2,213	2,144	2,969	3,700
Palm nuts	7,092	7,925	10,852	22,038	38,487
Cocoa	899	575	610	758	771
Ivory	272	292	211	346	267

The exports of copal, after having increased considerably in 1914, were greatly diminished during the war. The industry is again recovering, the export figures for 1917 being 7,329 tons. The exports of palm oil have shown an exceedingly rapid increase from 1,957 tons in 1912 to 5,309 tons in 1917. The exports of palm nuts, however, have increased even more rapidly, as will be seen from the foregoing table.

The export of coffee, which has only recently been attempted, has met with success. An attempt to export coffee in 1915 resulted in the sending of 29 tons abroad. In 1917, 167 tons were exported.

Many experiments have been conducted in rice culture, and the industry has met with considerable success on the upper Kongo in the Province of Orientale. In 1917 there were 693 tons exported.

Experiments in cotton culture have met with very good success, the production in 1920 being estimated at 4,000 bales of 550 pounds each.

The forests of Kongo are of great value, but difficult of exploitation, due to lack of transportation facilities. With proper facilities the Kongo should be able to export great quantities of wood for all purposes. In 1917 the export of woods of all kinds amounted only to 44 tons.

The great mining wealth of the Kongo is being rapidly developed, and the production of gold, copper, and diamonds is constantly increasing. In the diamond mines, located in the Province of Kasai, the output in 1914 was 23,837 carats; in 1915, 48,924 carats; in 1916, 53,941 carats. In the year 1917 the production almost doubled the 1916 output, being 99,960 carats.

The production of gold in the mines around Kilo and Moto in the Ituri District, has also been increasing rapidly. The annual production since 1914 is as follows, in troy ounces: 1914, 55,084; 1915, 83,929; 1916, 95,892; 1917, 113,725; 1918 (first 7 months), 102,040.

The war acted as a great stimulus on the copper-mining industry in the Kongo. In 1918 there were seven furnaces in operation around Elisabethville, capable of an annual output of 40,000 tons of copper Since 1913 the production has almost quadrupled, as shown by the following statistics; 1913, 7,048 metric tons; 1914, 10,722 tons; 1915, 14,054 tons; 1916, 22,149 tons: 1917, 27,462 tons The Province of Katanga is thus becoming one of the large copper-producing regions of the world. New mines are being extended and developed.

While the war stimulated the export trade of the Kongo, it caused stagnation in the import trade. In 1913 the value of the imports amounted to some £3,500,000; in 1917 the value had fallen to about £2,800,000

A general idea can be had of the import needs of the Kongo from a survey of the 1917 statistics. Noticeable among the imports are foodstuffs that cannot be produced in the country, or the production of which has not yet been developed, raw materials necessary to industrial development, and manufactured products of all kinds. The industrial growth of the Kongo is shown in the demand for iron and steel products, railway material, and machines and tools The Kongo has reached a stage in its development where the need of better and quicker methods of doing work, and better transportation facilities, is being keenly felt, and imports of all kinds of machines and tools, and railway materials should increase rapidly.

SANTONIN.

Some years ago the Government of India appointed a Drugs Manufacture Committee Many drugs which were formerly imported are now being obtained from Indian-grown materials. Dr. J. L. Simonsen, of the Forest Research Institute and College, Dehra Dun, writing in the "Journal of Indian Industries and Labour," calls the attention of the Committee to a possible further and important development, namely, the extraction of santonin from *artemesia maritima* grown in Kashmir. He is of opinion that the plant grown there contains enough santonin to be remunerative, and, from the information available, he says there would appear to be sufficient supplies of the raw material. It now only remains for the laboratory results to be utilised on the large scale. The method of extraction is comparatively simple, and the only chemicals required are lime, hydrochloric acid and alcohol, all of which are readily obtainable in India. As the leaves are bulky, the factory, it is suggested, should be in Kashmir, but as a preliminary arrangement might be made for extraction at the Medical Stores in Lahore.

The drug occurs in the young flower heads of *artemesia maritima* and finds an extensive use in medicine as a vermifuge. Prior to the war practically the whole of the world's supply came from Russian Turkestan, where the flower heads were gathered and the drug extracted. It has not been possible to obtain any recent data as to the size of the industry, but the area under *artemesia maritima* must have been considerable, since in 1885 one factory dealt with 1,600 tons of the flower heads. At that date there were apparently at least two other factories, but no information is available as to their output. The industry was conducted in a somewhat primitive fashion; the plants were pulled by the nomad inhabitants of the district, who stripped off the flower heads and used the remainder of the plant as fuel.

At this time the value of the santonin was estimated at £2 to £3 per kilo., but it could apparently be sold in Hamburg with a profit at 18 shillings a kilo. As a result of the unsettled conditions prevailing in Russian Turkestan no santonin is now being placed on the market, and the present price stands at the amazing figure of £50 per kilo. It is obvious, therefore, that some other source of supply of this valuable drug must be sought if adequate supplies are to be available once more.

GENERAL NOTES

THE CAMBRIDGE SCHOOL OF ARCHITECTURE.—A number of architects who are old Cambridge men have just formed a Club with a view to helping, wherever possible, the work of the Cambridge School of architecture. As a first step they have agreed to double the donation of £50 given this year by the R.I.B.A. to the funds of the School, and they propose in future to meet once a year, either in Cambridge or London, to establish relations with the staff of the School and to keep in touch with its work generally. Mr. Maurice E. Webb, F.R.I.B.A., has been elected Chairman of the Club and Mr. J. Alan Slater, A.R.I.B.A., Hon. Secretary and Treasurer.

THE FUEL RESEARCH BOARD.—It has long been felt that an important aspect of the great problem of the conservation of the national coal resources involves the study and classification of the coal seams which are at present being worked or developed, and also of seams or portions of seams which are being left unworked or are thrown aside above or below ground. This study and classification on its directly practical side must deal primarily with the

suitability of each particular coal for those purposes for which its individual qualities render it most adequate, e.g., for gas making, coke making, steam raising or for domestic use. This question of survey has for some years been receiving the anxious consideration of the Fuel Research Board, but the unstable conditions which prevailed in the coal industry during and since the war have necessarily led to the postponement of the work of organisation. It is now, however, considered that the time has arrived when a beginning can wisely be made. The Fuel Research Board believe that this work can be most effectively carried out with the help of local Committees in which colliery owners, managers and consumers are associated with the representatives of the Fuel Research Board and the Geological Survey. By this combination not only will local knowledge and experience be made available, but the initiative of those most deeply interested in the practical aspects of this survey will be secured. The survey work will thus from the outset assume a practical character, for the selection of seams for examination will be in the hands of those who are in the best position to estimate the relative importance of the problems awaiting solution. The selected seams will be submitted to physical and chemical examination by the local experts; and, as a result of this examination, a further selection will be made of those which appear to justify experiments on a practical scale to test their suitability for particular uses or methods of treatment. This experimental work will be carried out either at H.M. Fuel Research Station, or at other works, as may be found most convenient. The first Committee is already actively at work in the Lancashire and Cheshire district, where the local Research Association has been recognised by the Fuel Research Board as its representative body for the purpose. It is felt by the Fuel Research Board that the experience gained in the work and organisation of this Committee will be of great value in the establishment of Committees in other districts when the time is ripe for further developments, but they are satisfied that it will be wise to build up this national organisation on the sure foundations of actual experience.

THE INDIAN ANTIQUARY.—To celebrate the fiftieth anniversary of the publication of the "Indian Antiquary," Sir Richard Temple, Bt., who for thirty-seven years has been the Editor-Proprietor, has written a short account of the history of the magazine, which has had among its contributors many great Indian and Oriental scholars in India itself, as well as all over Europe and America. The object of the "Indian Antiquary" has been to provide a means of communication between the East and the West on subjects connected with Indian research, and a medium to which students and scholars, Indian and non-Indian, could combine to send notes and queries of a nature not usually finding a place in the pages of Asiatic societies. The main aim has been to promote and encourage research. The subjects with which the magazine has been principally concerned have been the Archæology, Epigraphy, Ethnology, Geography, History, Folklore, Language, Literature, Numismatics, Philology, Philosophy, and Religion of the Indian Empire, and, to a certain extent, of its surroundings. Notable contributions have been published on all these subjects, several of them having been preliminary studies of books subsequently well known to Indian and Oriental students, and even to general fame

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. :—

FEBRUARY 15.—CLOUDESLEY BRERETON, M.A., Divisional Inspector to the London County Council (Modern Languages), "The Necessity of Speech Training, and the Need of a National Conservatoire." SIR HENRY NEWBOLT, C.H., D.Litt., LL.D., Chairman of the Departmental Committee on the Teaching of English, in the chair.

FEBRUARY 22.—ALEXANDER SCOTT, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., in the chair.

MARCH 1.—EMANUEL MOOR, "The Duplex-Coupler Pianoforte." PERCY A. SCHOLES, Music Critic to the *Observer*, in the Chair.

MARCH 8.—W. A. APPLETON, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions." JOHN MURRAY, M.P., in the chair.

MARCH 15.—OSWALD T. FALK, "Certain Aspects of the Problem of Exchange Stabilisation." SIR ROBERT M. KINDERSLEY, K.B.E., in the chair.

MARCH 22.—PRINCIPAL A. P. LAURIE, M.A., D.Sc., F.R.S.E., "The Permanency of Oil Colours." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., in the chair.

MARCH 29.—SIR THOMAS OLIVER, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.)

APRIL 5. — PROFESSOR ERNEST R. MATTHEWS, "Sea Encroachment and its Prevention." LORD HEADLEY, M.Inst.C.E.I., in the chair.

APRIL 26.—JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry."

SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the chair.

Dates to be hereafter announced :—

LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

PHILIP SCHIDROWITZ, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

MAJOR PERCY A. MACMAHON, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock.

MARCH 24.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India."

APRIL 28. — F. G. ROYAL - DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the chair.

MAY 26.—PROFESSOR SIR THOMAS W. ARNOLD, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced :—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)." Date to be hereafter announced.

LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON G.B.E., K.C.M.G., "New Zealand." Date to be hereafter announced.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETINGS.)

Friday afternoons, at 4.30 o'clock.

FEBRUARY 24. — PROFESSOR WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., "Brown Coals and Lignites: Their Importance to the Empire." VISCOUNT ELVEDEN, C.B., C.M.G., M.P., in the chair.

MAY 5.—PROFESSOR WILLIAM HENRY ECCLES, D.Sc. (London), F.R.S., "Imperial Wireless Communication."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." Three Lectures. February 20, 27 and March 6.

Syllabus.

LECTURE I.—FEBRUARY 20.—Design from the point of view of the User and the Manufacturer—Clerk Maxwell's axioms of Instrument Design—Degrees of Freedom and Constraint—The Six Degrees of Freedom of a Rigid Body—Geometric Design.

LECTURE II.—FEBRUARY 27.—The Lower and Higher Pairs—Restraint against Sliding—Restraint against Rotation—Centrodes and Axodes—The Design of Profiles.

LECTURE III.—MARCH 6.—The Elastic Nature of all Materials—The Elastic Constants—The Rigidity of Instruments—Manufacture—Models—Interchangeable Manufacture.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

COBB LECTURES.

Monday evenings, at 8 o'clock.

F. F. RENWICK, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, FEBRUARY 13..Health, People's League of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Dr. R. H. Cole, "Sensation, Perception, Idealism and Attention."

Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m.

Electrical Engineers, Institution of (North-Eastern Centre), Armstrong College, Newcastle, 7.15 p.m. Mr. F. P. Whitaker, "Rotary Converters, with special reference to Railway Electrification." (Dundee Sub-Centre), University College, Dundee, 7.30 p.m. Mr. J. W. Beauchamp, "Publicity and Electrical Development."

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W. (1) Prof. J. R. Partington, "The Energy of Gaseous Molecules." (2) Mr. U. R. Evans, "Passivity and Over Potential." (3) Prof. A. W. Porter, "Note on the Vapour Pressure of Ternary Mixtures."

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Sir Henry White-Smith, "The Development of Commercial Airways."
Chemical Industry, Society of (Glasgow Section), 39, Elmbank Crescent, Glasgow, 7.15 p.m. Mr. D. N. McArthur, "Some Chemical Problems in Agriculture."

TUESDAY, FEBRUARY 14.. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. J. E. Hachford, "The Significance of the Interpretation of the Chemical Analyses of Seepages."
Rubber Industry, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.45 p.m.
Anthropological Institute, at the Royal Society, Burlington House, Piccadilly, W., 8.15 p.m. Prof. G. E. Smith, "The Brain of Rhodesian Man."
Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Colonel T. C. Hodson, "Head Hunters at Home."
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Dr. Horn. "The Belgian Congo Administration in the Congo and the Mandatory Territory."
Dyers and Colorists, Society of (West Riding Section), Mr. F. E. Lamplough, "Artificial Daylight."
British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. R. A. Dawson, "Celtic Art—its Development in Christian and Pre-Christian Times."
University of London, at the London School of Economics, Houghton Street, Aldwych, W.C., 6 p.m. Sir Josiah Stamp, "The Administrative Factor in Government." (Lecture I.)
Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Colonel T. C. Hodson, "The Primitive Culture of India." (Lecture IV.)
Metals, Institute of, Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Prof. F. C. Lea, "Light Aluminium Alloys." (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. (1) Mr. J. A. Sillars, "The Production of Lead Pipes by the Extrusion Method." (2) Mr. H. J. Brand, "The Smelting and Refining of Zinc."
Royal Institution, Albemarle Street, W., 3 p.m. Prof. H. H. Turner, "Variable Stars" (Lecture III.)
Electrical Engineers, Institution of (East Midland Sub-Centre), The College, Loughborough, 6.45 p.m. Discussion on "Mercury-Arc Rectifiers." (Scottish Section), 207, Bath Street, Glasgow, 7.30 p.m. Major J. Erskine-Murray, "The Use of Wireless, Past and Present." (North Midland Section), Hotel Metropole, King Street, Leeds, 7 p.m. Messrs. L. J. Steele and H. Martin, "The Cyc-Arc Process of Automatic Electric Welding."
Textile Institute, 16, St. Mary's Parsonage, Manchester, 4 p.m. Mr. W. Bailey, "Recent Developments in Winding and Doubling."
Photographic Society, 35, Russell Square, W.C., 7 p.m. (Technical Meeting). (1) Prof. Dr T. Svedberg (*a*) "On the relation between the Size of Grain and Sensitivity of Photographic Emulsion (Part II); (*b*) The Reducibility of the Individual Haloid Grains in a Photographic Emulsion. (2) Mr. K. C. D. Hickman, "An Optical Method of Testing Washing Devices, together with a Demonstration of some Wasting Devices."
Transport, Institute of (North-Western Section), The University, Liverpool, 5.30 p.m. Mr. F. E. Bixandale, "Some Notes on Railway Operations, Past, Present and Future."

WEDNESDAY, FEBRUARY 15.. African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Sir Robert Coryndon, "Problems of Eastern Africa."
Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Dr. L. D. Barnett, "The Jains."
Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. M. S. Paterson, "The Success and Failure of Sanatoria Treatment."
Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Sir George Paish, "Industry and its Relation to Finance."
Meteorological Society, 49, Cromwell Road, S.W., 7.30 p.m.
Microscopical Society, 28, Hanover Square, W. 8 p.m. Mr. A. L. Booth, "The Microstructure of Coal from an Industrial Standpoint."
Royal United Service Institution, Whitehall S.W., 3 p.m. Colonel-Commandant L. C. L. Oldfield, "Artillery and the Lessons we have learnt with regard to it in the Late War."
Electrical Engineers, Institution of (Sheffield Sub-Centre), Royal Victoria Hotel, Sheffield 7.30 p.m.

THURSDAY, FEBRUARY 16.. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi W.C., 5.30 p.m. Sqdr.-Ldr. C. F. A. Portal "Methods of Instruction in Aeroplane Flying."
Antiquaries, Society of, Burlington House Piccadilly, W., 8.30 p.m.
Royal Society, Burlington House, Piccadilly W., 4 p.m.
Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. G. Perkin, "Dyeing—Ancient and Modern." (Lecture I.)
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Mr. F. P. Whitaker, "Rotary Converters with special reference to Railway Electrification."
Constructive Birth Control and Racial Progress Society for, Essex Hall, Essex Street, Strand W.C., 8 p.m. Mr. E. B. Turner, "Sex Relationships."
Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.
Chemical Society, Burlington House, Piccadilly W., 8 p.m. (1) Mr. A. W. Lapworth, "A Theoretical Derivation of the Principle of Induced Alternate Polarities." (2) Messrs W. O. Kermack and R. Robinson, "An Explanation of the Property of Induced Polarity of Atoms and an Interpretation of the Theory of Partial Valencies on an Electronic Basis."
Auctioneers' and Estate Agents' Institute, 34 Russell Square, W.C., 7.30 p.m. Mr. C. H. Closh, "Mortgage Valuations."
China Society, at the School of Oriental Studies Finsbury Circus, E.C., 5 p.m. Miss E. G. Kemp "Some Aboriginal Tribes in China."

FRIDAY, FEBRUARY 17.. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi W.C., 5 p.m. Colonel J. A. Saner, "British and Foreign Canals and Waterways Compared."
Japan Society, 20, Hanover Square, W., 5 p.m.
Royal Institution, Albemarle Street W., 9 p.m. Dr S. M. Watson, "History of the Mammalian Ear"
Metals Institute of, The University, Sheffield 7.30 p.m. Joint Meeting with the Institution of British Foundrymen.
University of London, King's College, Strand W.C., 5 p.m. Prof. R. Robinson, "Orientation and Conjugation in Organic Chemistry from the Standpoint of the Theories of Partial Valency and the Latent Polarity of Atoms" (Lecture II.)
Geological Society, Burlington House, Piccadilly W., 3 p.m. Annual General Meeting. Address by the President.
Photographic Society, 35, Russell Square, 8 p.m. Address by Prof. Rothenstein.
Mechanical Engineers, Institution of, 6 p.m. (1) Annual General Meeting. (2) Mr. A. T. Wall, "Electric Welding applied to Steel Construction with special reference to Ships."
Chemical Industry, Society of (Liverpool Section) The University, Liverpool, 6 p.m. Prof I. M. Heilbron, "The Photosynthesis of Plant Products."
Engineers, Junior Institution of, Caxton Hall Westminster, S.W., 8 p.m. Mr. W. J. Leaton "Water Purification for Boiler-Feed Purposes."

SATURDAY, FEBRUARY 18.. Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. A. Gardner "Masterpieces of Greek Sculpture. (Lecture I.)
Chromatics, International College of, Caxton Hall, Westminster, S.W., 3.15 p.m. Mr F. C. Reynolds, "An Experimental Demonstration of the Colours produced by Polarised Light."

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

***For Meetings of the ROYAL SOCIETY OF ARTS, see page 22.**

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FRIDAY, FEBRUARY 17, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 20th, at 8 p.m. (Cantor Lecture.) ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." (Lecture I.)

WEDNESDAY, FEBRUARY 22nd, at 8 p.m. (Ordinary Meeting.) ALEXANDER SCOTT, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., in the chair.

FRIDAY, FEBRUARY 24th, at 4.30 p.m. (Joint Meeting of Dominions and Colonies and Indian Sections.) WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, "Brown Coals and Lignites: Their Importance to the Empire." VISCOUNT ELVEDEN, C.B., C.M.G., M.P., in the chair.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 8th, 1922; Mr. W. J. U. WOOLCOCK, C.B.E., M.P., in the chair.

The following candidates were proposed for election as Fellows of the Society :—

Gidney, Lieut.-Col. Henry A. J., F.R.C.S., D.P.H., J.P., M.L.A., I.M.S. (retired), Delhi, India.

Khan, Ghulam Mohd, Lyallpur, India.

The following candidates were balloted for and duly elected Fellows of the Society :

Beadle, Ormond Alec., Oxford.

Chettiar, Rao Sahib P.K.A.C.T. Veerappa, M.B.E., Kottaiyur, Madras, India.

Oppenheimer, Maurice, Rangoon, Burma.

Taylor, Samuel Daniel, Oxford.

A paper on "Some Solved and Unsolved Problems in Gas Works Chemistry," was read by Mr. EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company.

The paper and discussion will be published in the *Journal* of March 10th.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, JANUARY 27TH, 1922.

SIR WILLIAM S. MEYER, G.C.I.E., K.C.S.I. (High Commissioner for India), in the chair.

THE SECRETARY OF THE SECTION announced that the Secretary of State for India was unable, to his very great regret, to fulfil his promise to take the chair at the meeting, owing to urgent public business, but the High Commissioner for India had most kindly consented at very short notice to take Mr. Montagu's place. Mr. Montagu had sent a message to say that he had been looking forward with great pleasure to the meeting, and it was a great disappointment to him that the exigencies of public life prevented him from being present.

THE CHAIRMAN said he must ask the meeting to accept him as a very inadequate substitute for Mr. Montagu, whose absence had been explained by the Secretary. Personally, he knew that Mr. Montagu very much wanted to attend the meeting, but even Cabinet Ministers were not their own masters nowadays, and Mr Montagu was one of the victims of the Cabinet habit. The author of the very interesting paper on "The Timbers of India and Burma" to be read at the meeting was his friend, Mr. Alexander Howard, who was one of the greatest living authorities on the subject. He was the head of one of the great timber firms of the Empire, and was also a writer on the subject. He had written a most valuable manual on the timbers of the world, and had from time to time written most interesting brochures on some of the timbers of India. Mr. Howard had

a very special connection with India, because for the last few years his firm had been the Agents for the Government of India and the Provincial Governments in connection with the sale of Indian timbers and articles made from them in this country. In that capacity Mr. Howard had rendered very great service, and although his modesty had prevented him from saying so in the paper, the developments that were mentioned were very largely due to his personal initiative and knowledge. Mr. Howard also took a very great share in the splendid representation of Indian timbers at the Empire Timber Exhibition in 1920. Probably a good many of those present visited that Exhibition, and they must have been very much gratified by the prominent part that India took there. Mr. Howard and himself had come into close official contact, because under the system of "dyarchy," which now prevailed in London as well as in India, in regard to Indian affairs, the dyarchs in this country being the Secretary of State and the High Commissioner, he had taken over the supervision of the work of Mr. Howard's firm in connection with the sale of Indian timbers. He had found him a most genial and efficient comrade, and desired to express the great obligations he was under to him in the decoration of the offices at Grosvenor Gardens. The panelling and flooring of some of the public rooms there were to be done in Indian timbers, and the furniture was to be made of Indian wood. Each room would have a special scheme: there would be a padauk room, a laurel-grey room, and so on. Mr. Howard had given most valuable advice on the subject and was very keen about it, because he rightly argued that it was not a mere question of æsthetic decoration, but of commercial expediency. Every now and then people came to Mr. Howard, and when he recommended them to furnish rooms with Indian woods and furniture, they said it was impossible for them to judge what could be produced from the specimen slabs of wood that were exhibited, and that they would like to see how a room panelled and floored with Indian woods would look. In future Mr. Howard would be able to send such people to the High Commissioner's offices in Grosvenor Gardens, where they would be able to see rooms so fitted, and it was hoped in that way that the market for Indian timbers in this country would be very considerably developed. Unfortunately, Mr. Howard was not present to read his paper, as he had had to leave England on urgent business, and in his absence it would be read by his kinsman, Mr. A. A. Hannay, while the views that would be shown on the screen would be explained by Sir George Hart, late Inspector-General of Forests to the Government of India.

MR. HANNAY, before reading the paper, said he was desired by Mr. Howard to express his deep regret that he was unable to appear in person in recognition of the distinction conferred upon him in being invited by the Society to read a paper on a subject in which he was so deeply interested.

The paper read was:—

THE TIMBERS OF INDIA AND BURMA.

BY ALEXANDER L. HOWARD.

To-night I am to address you upon the timbers of India and Burma, and I must confess to have felt some little anxiety as to the manner in which I am to treat this subject before so distinguished an audience.

My friend, Mr. H. J. Elwes, of Colesborne, speaking after Professor Troup's lecture last January, said he hoped that it would be followed by one written from the commercial side, which would give an idea of what was practicable from that stand-point. This is important, for, after all, one of the chief aims in the prosecution of a scientific forest policy is to make the forests yield the highest possible sustained revenue for the owner; in other words, always provided that the upkeep of the forest estate is assured, the object in view is commercial and practical.

It is, therefore, as one with a practical experience of timber and its uses, and with a knowledge of the timber market, that I have been invited here to-day. In addition to this double equipment, I may perhaps speak with further confidence about Indian timbers, since within this last year I have made an extended tour through some of the chief timber-producing areas of India, Burma, and the Andaman Islands, with the object of gauging their possibilities for the development of trade.

Consequently, in considering my paper beforehand, I have been guided by the aim of supplementing the knowledge of forestry and the botanical structure of wood which many of you doubtless possess in a large degree, by my commercial and practical experience. We are anxious to bridge over the gulf, still too apparent, between abstract science and commercial activity. An appreciation of the needs, the difficulties and the problems of the industrial world must guide the trend of scientific research, if industry and science are to further their mutual interests.

I think that in England this point still requires emphasising. We want this mutual dependence of science and trade to be more generally recognised, and we need to modify our industry by scientific knowledge and method. Important points about wood, such as durability, colour, grain, and possible uses—often dismissed as of trade interest only—are as worthy of attention and as worthy of a place in the complete understanding of a wood, as are the purely botanical aspects. Indeed, a scientific knowledge of wood which ignores these points is one-sided and does not justify its name, for science in its widest significance embraces observed phenomena of all kinds.

That the importance of this point with regard to these woods has already been recognised in India is proved by the work done at the Research Institute at Dehra Dun, and, again, may be seen by the Report of the Indian Industrial Commission which was published in 1919, in which the exploitation of the forests on more commercial lines, and the necessity of commercial methods in rendering their products available for industrialists, is imperatively insisted on, and this is what I also wish to emphasise to-night.

No one who has seen the furniture and other works in Indian woods as they have been produced here by our English craftsmen can fail to appreciate their great beauty and distinction. Still, from the point of view of timber consumers in this country, the chief considerations are purely practical factors, such as the f.o.b. (the "free on board") price, the cost of freight, and whether there is a sufficiency of the timber to guarantee steady and continuous supplies.

My experience in the trade has forced me to the conclusion that in many timber-producing countries, particularly in the tropics, the timbers which are most esteemed by local inhabitants often prove to be the least valuable for export. On the other hand, timbers which are of little use in the country of their origin are not seldom of great importance in parts of the world with different climatic conditions. Thus it is unlikely that the deodar and the sal, which are the principal timbers of Northern and Central India, would be successful in British and European markets, while woods such as Indian white mahogany, laurel-wood, gurjun, white bombwe, silver greywood and white chuglam, all of which may be expected to prove of very considerable value in home markets, are in small demand in India. The consequence of this is that the majority of Indian timbers likely to be appreciated by consumers in Europe are, in default of any large local demand, obtainable at a price far below their intrinsic value, and so the f.o.b. price for these timbers is, for the present at all events, very advantageous to the buyer.

Then there is the cost of freight. Since the Armistice, freights, which during the war and immediately after soared to a point previously unknown, have become more and more reduced till now they are often less than they were before the war. Shipping freight cost is always rather a speculative affair, and undoubtedly if it were to go up again to anything approaching that of the war years, the trade in the timbers of India and Burma would be very adversely affected, though even in such a case, I do not think it would be utterly ruined. However, it does not appear that there is the slightest prospect of any material change from present conditions for some time to come.

I was able, when in India, to lay the foundations of a scheme which has since enabled us to have direct shipment of timber from Indian and Burmese ports, and from the Andaman Islands. Altogether some five or six ships have been employed during the last few months, one of which is now loading at Rangoon. The first ship to be so utilised was the ss. "Rhodesia," which arrived at the West India Docks from Rangoon in August last, with a full cargo from the Government of Burma of fine teak logs of large size. This import of round teak logs has given rise to an animated discussion in the technical press on the comparative advantages of bringing the timber over as it comes from the forest, instead of in sawn squares, which is the form in which teak has been imported in the past. I do not intend to trouble you further on this subject, except to say that while at the start I believed that the import of round logs would be beneficial both for the producer and the consumer, I am now convinced by experience of the advantage of marketing the timber in this form.

With regard to the sufficiency of the timber supply, there is no question as to this, when you realise that the Government forests occupy an area of 251,000 square miles. Reflect for a moment that the whole

FIG. 1.—Teak Logs on Dragging Path. Prepared with Cross Billets.

area of Great Britain is 88,000 square miles, and that in India and Burma there are 251,000 square miles of forest.

There remains one element to be considered: and this is, whether the Government of India, through the officers of the Forest Service, will continue the energetic and progressive policy which they have lately adopted. Of the efficiency of the Indian Forest Service it is quite unnecessary for me to speak to you here to-night, for it will be known to you all and is beyond question. All Governments and Government servants, however, are at some disadvantage in carrying out any commercial enterprise, and the local Governments of India and Burma are no more free from this disability than any others.

I would, therefore, earnestly direct the attention of the authorities concerned to the paramount necessity of obtaining a thorough grasp of the commercial conditions in Europe, so that they may realise, for instance, the importance of producing their timber for the market in the manner and in the quantities which are required by the buyers. Only by such a proceeding will it be possible to garner the immense harvest of revenue which is available, but which is so absolutely dependent upon this point.

Personally, I am convinced that it is only by actual Government initiation and exploitation that these timbers can be brought into common use. For many years Government have endeavoured to encourage private trading firms to exploit these lesser-known native timbers, but they have so far met with little success, and I do not think they will meet with much more in the future. The whole problem suggests itself as too complicated and hazardous an enterprise for any private, or public, corporate trading concern to undertake, until it has been established by the Government on a firm and substantial basis. It may be argued that both Government assistance and co-operation in forest industry have been largely dispensed with in other countries, and that this might well be so in India. The answer to this is that in most countries where private enterprise in forest industry has been pre-eminently successful there has been unlimited freedom and independence of action throughout the industry. In British India, however, the forests are the property of Government, and Government is pledged to manage them with the object, not only of maintaining them in their

present condition, but of improving them to the greatest possible extent in the interests of future generations. Unlimited freedom of action for private enterprise is, therefore, impossible in India. I am convinced that the great expense to which the Government of India have been put, and the advantages which have already been gained in the development of this industry, will all be of no effect unless the considerations which I have outlined are borne in mind.

I am afraid that the economic use of timber, with which is bound up its suitability for various industrial purposes, is better understood elsewhere than it is in England. Our hide-bound repetition of the use of oak, mahogany and walnut has become almost ludicrous in face of the wide field of choice that now lies before the artist, the architect, and the craftsman. It is this circumscribed outlook which causes a wood to continue in demand long after the original reason for its adoption—

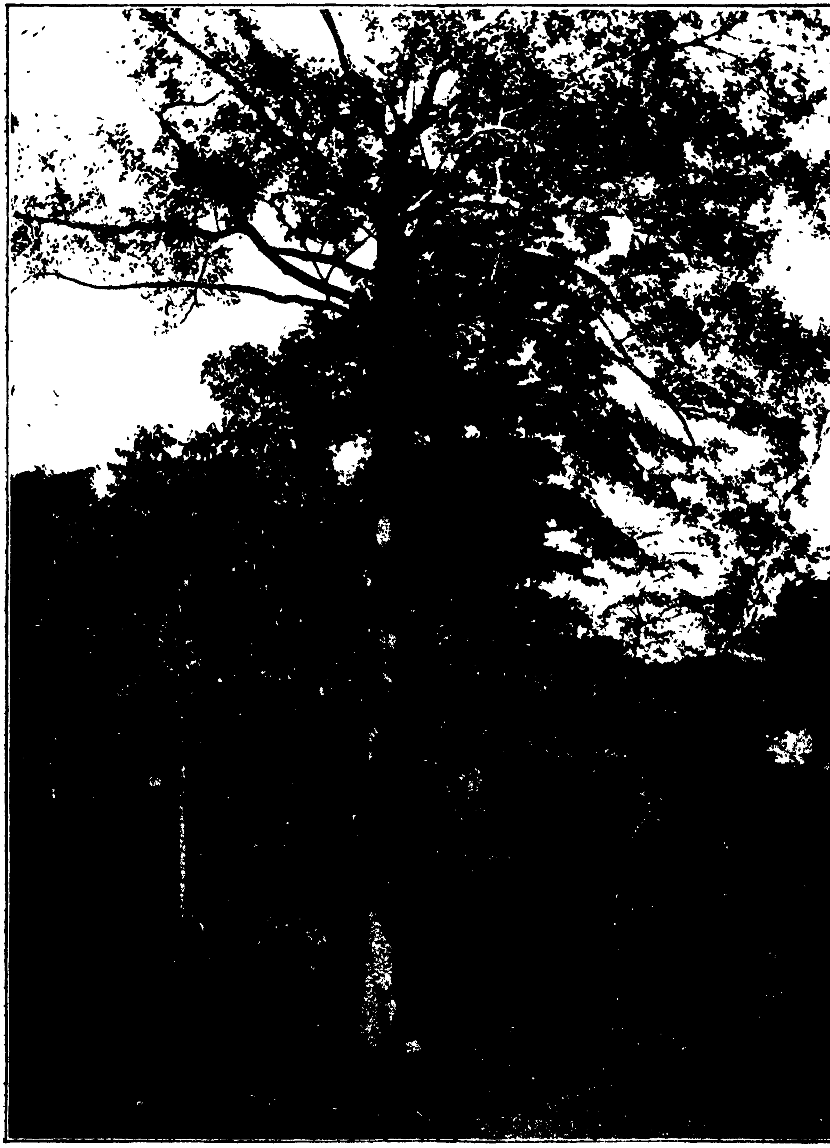

FIG. 2.—Eng, Lower Burma.

cheapness, abundance of supplies or what not—has ceased to exist. I have just returned from a tour through France, Germany, Holland and Belgium, and I found that existing conditions practically limit the use of timber in these countries to home products, for the adverse rate of exchange makes any other course too extravagant. Yet I found a better knowledge and understanding of the woods used than exists in this country; for the woods are chosen, firstly, with due regard to the needs and resources of the country, and secondly, on their own actual merits for the specific purpose in view. I might say, however, that in my experience the English woodworking craftsman stands supreme in the results which he can achieve.

Here in England it seems to be our custom to belittle the value both of home and of Empire grown timber, with the result that foreign woods have been exploited to the detriment of our own. While this is a questionable policy from the patriotic point of view, it is also certainly near-sighted and indefensible economically, for it tends to force the price of the timber to a point beyond its natural value. A noteworthy and commendable exception may be noticed in the action of the Bank of England, which, notwithstanding considerable opposition from various quarters, has had the whole of the decorative woodwork in its new buildings in Finsbury Circus made of Indian timbers. This example has been followed by many others, and amongst the works recently completed in these woods I may mention the following:—

London County Hall (Holland & Hannen & Cubitts, Ltd.) — Laurel-wood panelling.

Francis Peek & Co., Eastcheap (Holland & Hannen & Cubitts, Ltd.)—Padauk, laurel-wood, silver greywood and gurjun panelling and fittings.

Blade, East & Blade, Cannon Street, London—Silver greywood fittings.

Guardian Assurance Co., London (Higgs & Hill, Ltd.)—Laurel-wood and koko panelling and fittings, gurjun block flooring (Stanhope Flooring Co.).

General Electric Co., Birmingham (Elliott & Sons, Reading)—Silver greywood panelling, silver greywood lift (Express Lift Co.).

Bovis, Ltd., London—Padauk panelling (Bovis, Ltd.).

Mr. Llewellyn, Gloucester (Elliott & Sons) —Rosewood panelling.

Barclay's Bank, Palmers Green (Stapleton & Co.)—Padauk fittings.

Great Eastern Railway Co.—Silver greywood and padauk Pullman car fittings.

Great Eastern Railway Co. Showrooms—Silver greywood parquet flooring.

Clan Line Steamships (A. J. Norris & Co.) —Padauk panelling and fittings.

Spink & Co., London—Showroom and warehouse gurjun flooring.

Reading Corporation Tramways—White mahogany tram-car panelling.

Emanuel & Co.—Bedroom suites in white mahogany.

Coals, Lovell & Co.—Dining room suites in white mahogany.

Robersons, Ltd.—Dining tables in padauk.

Caffall & Co.—Chairs in koko.

Burroughes & Watts—Billiard tables in padauk.

Cramer & Co.—Pianofortes in white mahogany (cases).

To give you an idea of how small the Indian timber imports have been in the past, I may mention that in 1913, a typical pre-war year, the value of the timber imported into the United Kingdom amounted to £33,788,884, of which only £739,515 was due to India, teak accounting for 94 per cent. of India's share. During last year Indian timber imports largely increased, though complete statistics are not yet available.

There are nearly 2,500 different species of timber trees to be found in India, Burma, and the Andaman Islands. Only a small proportion of these are of economic interest, and very few of them were known to timber buyers in England before the Empire Timber Exhibition of 1920. The qualities of these woods are not very well known in India either, for, strangely enough, in the teak-bearing tracts timbers are generally described as "teak and jungle-woods." This derogatory term "jungle-woods" is, of course, detrimental to the trade. It is, also, an unmerited slur, and an absurd depreciation, for among these so-called jungle-woods we have found logs the individual value of which has exceeded that of the finest mahogany or satinwood: moreover, there has recently been discovered among them a wood which equals, if it does not exceed in value, any boxwood which the world can produce.

In the short space of time at my disposal to-night, it is impossible to deal adequately with this great variety of woods, and I must content myself with speaking of a very few of the most noteworthy, though I have here a number of panels of various Indian woods which I think you will find worth examination. That such excellent results can be achieved will, I fancy, surprise you, and more particularly, perhaps, those of you who may be familiar with the timbers of India only in their native country and when prepared by native craftsmen.

LAUREL-WOOD.

Though from a very early date walnut has been used for furniture and decorative work throughout Europe, it seems to me undesirable that works of art, whose beauty makes them worthy of permanence, should be executed in walnut, for this wood is almost invariably attacked by boring beetles, which ultimately destroy the whole fabric. The artistic appearance given by the warm tones and fine figure of walnut is one of the principal reasons for its selection. The Indian laurel-wood provides this

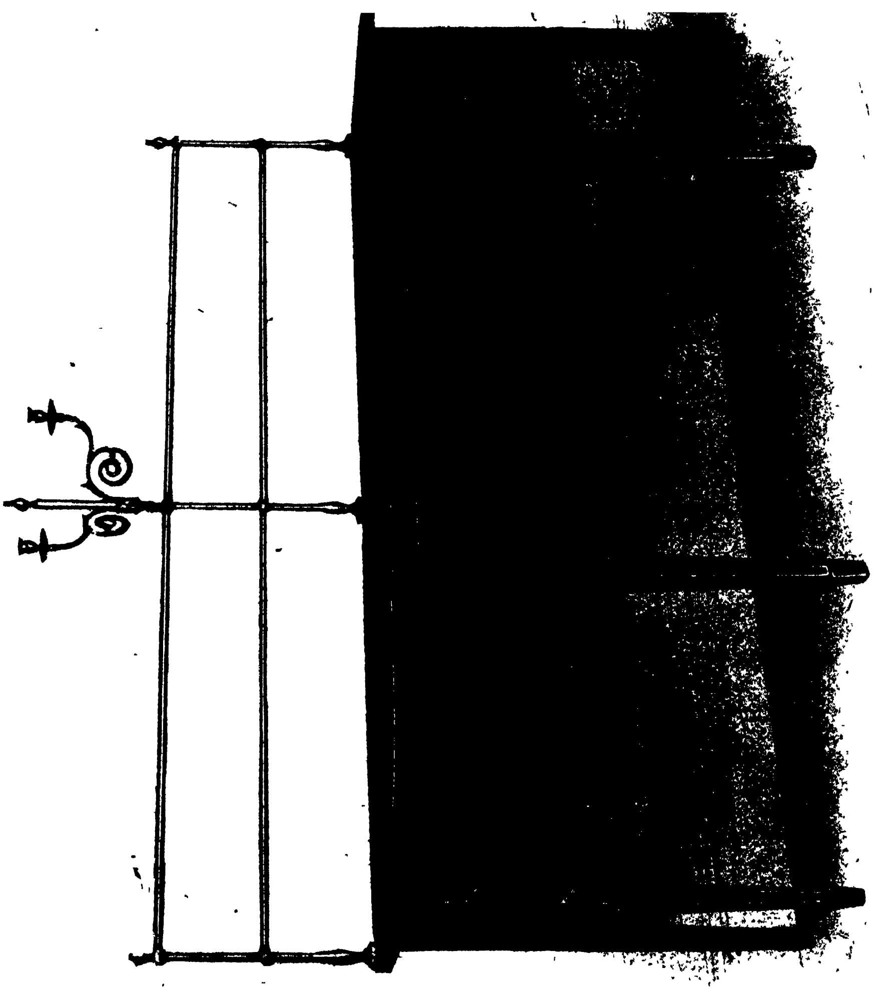

FIG. 3.—Sideboard in Laurel Wood and Red Zebra Wood.

also in a superlative degree and is, I venture to say, the most beautiful wood that India can provide. Its durability, in contrast to walnut, for which it will be an excellent substitute, may, in my opinion, be regarded as beyond question.

GURJUN.

Those who wish to see a beautiful example of work in this wood, and, by the way, of laurel-wood and of padauk also, should ask for permission from the firm of Messrs. Francis Peek & Co. to visit their building in Eastcheap, where there is some fine gurjun panelling. Among other instances of the use of this timber I may mention the flooring recently put down in the new Bank of England building in Finsbury Circus; the ball-room floor laid 15 years ago for Mr. Trevor-Battye, who tells me that it is admired by all who see it; and the railway coach constructed by the Great Eastern Railway Co., which has proved so satisfactory that other leading railway companies are now using this timber for coach work.

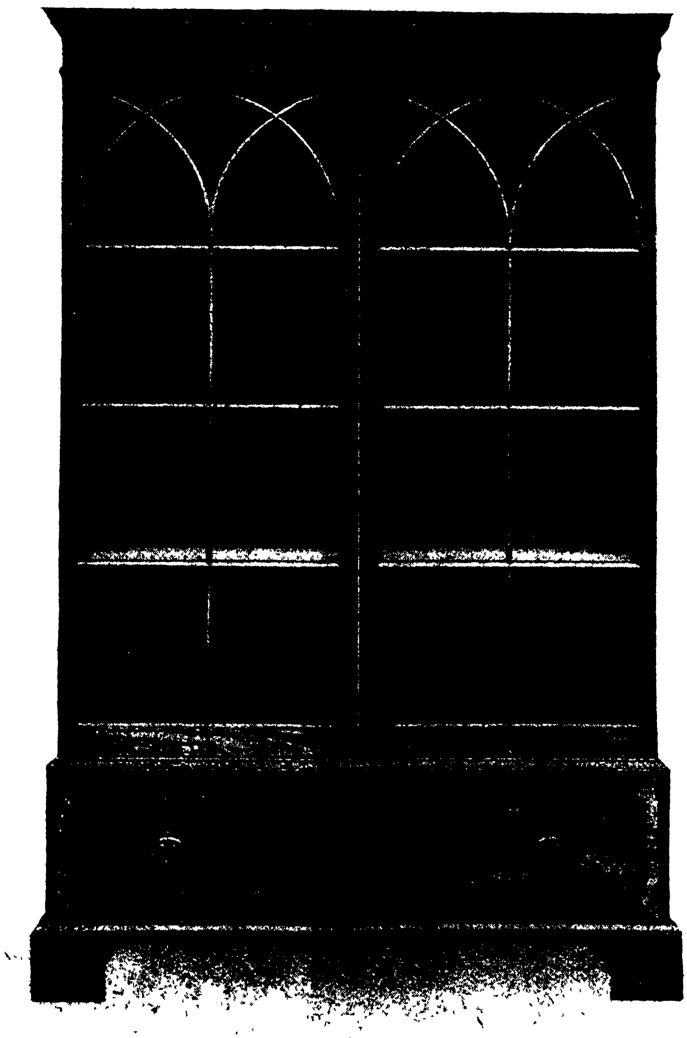

FIG. 4.—Indian Silver Greywood Cabinet.

One of the great advantages of this timber is that it is available in very long lengths and large sizes, free from any defect, while as the result of breaking-tests which have been made it has proved to be stronger than British oak. One of my friends who has tested gurjun for breaking strain has brought to light rather a curious fact. It was found that not in one single test was it possible to break the wood right through so that one piece was severed from the other. In each instance two pieces continued to be jointed together by what appeared to be a tough outer skin which thus formed a kind of hinge.

I would like to add one word in connection with this wood, and that is that it should never be used for joinery, carpentry, or any other work of importance, unless it is thoroughly seasoned; also that whenever possible it should be sawn on the quarter. When cut on the tangential section it is liable to shrink and warp, and this is particularly noticeable if the wood be not completely seasoned.

INDIAN SILVER GREYWOOD.

This is a beautiful wood, but it needs careful selection according to the use for which it is required. Supplies can be obtained which display a uniform grey shade with a tinge of green in it and a beautiful silvery lustre; others have varying streaks of lighter and darker colouring, while occasionally very varied and wild marking is seen. It is desirable that the wood be selected by the craftsman, so that the completed work may present a harmonious effect, and not a medley of different variations, which, though in themselves very beautiful, mar the effect when placed in juxtaposition. The specimens of panels and of parquet flooring in silver greywood which are shewn here will give you an opportunity of seeing how this selection ought to be made. With exposure to the air the colour improves, though it is inclined to darken slightly. One great recommendation of the wood is that the colour is permanent, in which respect it is unlike the so-called "greywood," which is stained sycamore, that is so much in use.

In addition to those works in silver greywood of which I have previously made mention, it has been used for parquet flooring in a number of private houses. Some very beautiful furniture was also made of this wood for the Exhibition, and it may be said that there is a great future before it.

PYINKADO.

This is the ironwood of Burma. I measured a tree in the forest which had a clear stem of 50 feet to the first branch and at breast height it girthed 17 feet 3 inches, which is equal to a diameter of approximately 5 feet 9 inches, and the trees commonly grow to a height of 90 to 100 feet.

If the pyinkado had grown in America, I venture to say that the whole world would have heard of its wonderful qualities of strength and durability. Lieut.-Col. Blake, Commissioner at Moulmein, writing in 1875, said that the wood was heavier than water and more indestructible than iron, while the teredo would not touch it. He added:—"There is a piece of this wood which supported a teak figure of Godama, taken from Rangoon in 1826, standing in a lake near. The teak figure has long since mouldered away into dust, but at the pillar I fired a rifle shot at 20 yards distance; the ball was thrown back, making no penetration whatever." What a wonderful tribute this is to the durability of pyinkado! If the teak figure had "long since mouldered away into dust," how old must the standard have been?

Though this timber is very hard it can be sawn and worked without much difficulty when comparatively fresh.

PADAUK.

Much as I know of the beauty of Andaman padauk when used in decorative furniture work, I had never before realised how beautiful it could be until I saw the work at Messrs. Francis Peek & Co.'s building in Eastcheap. This work was carried out by Messrs. Holland & Hannen & Cubitt's, and the head of their joinery shops deserves no small measure of praise for its success. Apart from the inherent brilliancy of the wood, a new feature appears to be noticeable here. This is that the padauk seems to be endued with a living fire, which flashes and dulls with the alternations of light and shade. This quality is strikingly noticeable even in the daylight, but by artificial light it is much enhanced.

The padauk of Burma is of a duller colour but nevertheless it is a rich and beautiful wood, and it also possesses strength, toughness and elasticity to a marked degree.

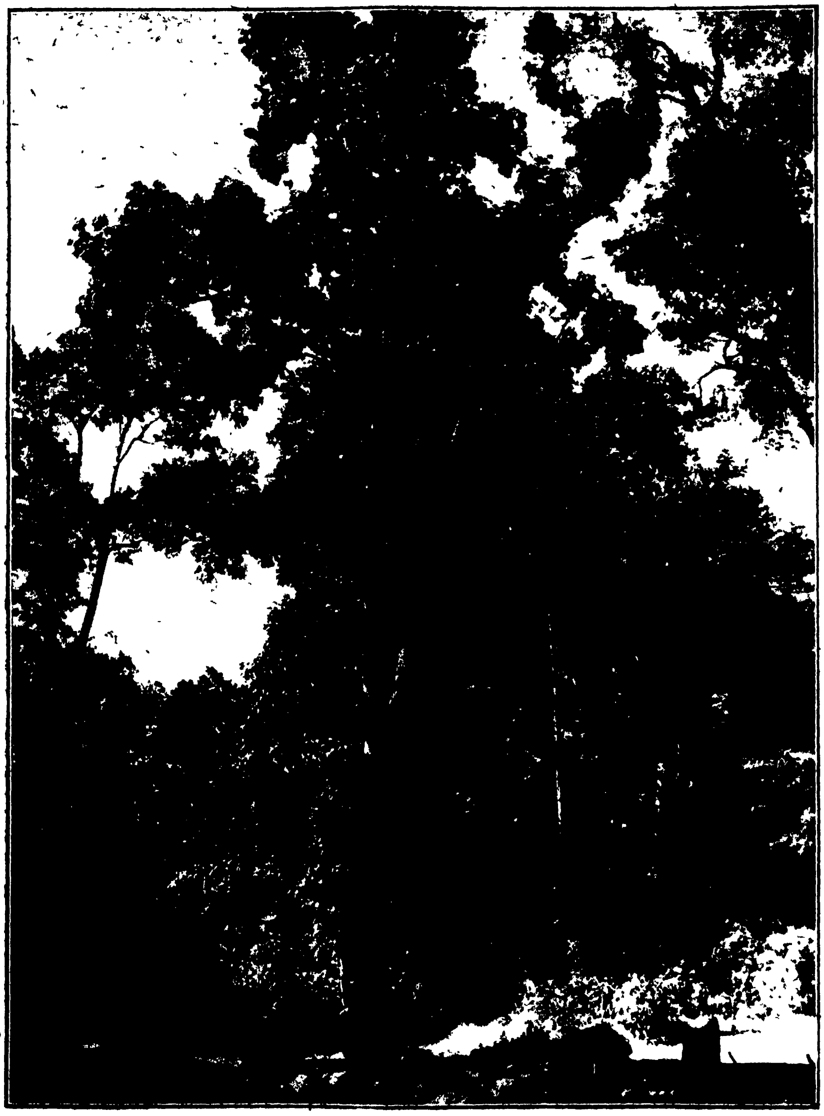

FIG. 5.—Pyinkado, Lower Burma.

Both this wood and the Andaman padauk have been approved by the Admiralty as a substitute for sabicu for the particular purpose for which this West Indian wood is used in the construction of battleships.

INDIAN BOXWOOD.

I propose here to treat of a wood which, but for one point, would come in a different place in this catalogue. This is a wood which we have named Indian boxwood, for though it is not a true boxwood, it yet greatly resembles it in appearance and growth. Similarly, the West Indian boxwood, one of the most useful in commerce, does not belong to the genus *Buxus*.

Now, one of the ever-present troubles which confronts the user of boxwood has been its great tendency to split, either when stored in the log or when manufactured. A shipment of this Indian boxwood, which was sent over to us before the Exhibition of 1920, has since been found to contain two different kinds of wood. One of these apparently does not split in the log or when cut up, or after manufacture,

while the other is liable to do so under all these conditions.

I have here two sections shewing the different behaviour of these two kinds. I have also a croquet mallet made from the non-splitting kind, which in all other respects as well is as good as any that could be made.

By all those who are aware of this difficulty, which true boxwood so often presents, the great value of Indian boxwood will be immediately recognised.

Haldu.

When riding through the jungle near Bawbin in Burma, we suddenly came on a gigantic haldu tree towering up in a small clearing, and I was able to take a photograph. I measured the tree, which had a clear stem of over 80 feet free from any branch, and the buttressed butt-end measured 19 feet in length with a girth of about 17 feet, which is 5 feet 8 inches in diameter. The perfect log, cylindrical up to the first branch, measured 49 feet by 11 feet 2 inches or about 3 feet 6 inches in diameter. The top section, branched but straight, measured 55 feet by about 7 feet 6 inches in girth. There were also sundry other branches.

Apart from the beautiful colour of this wood, which is of a gambogo shade, somewhat resembling satinwood, it is interesting for the remarkable quality of the grain. Unlike the majority of woods, it is possible to work it in any direction with the greatest facility and without splitting. It is a splendid chair wood—the copy of a Hepplewhite chair which I have had made in haldu is perfect—while the colour is most artistic and agreeable. There are other special kinds of work for which this wood is exceptionally fitted, and amongst them I might mention particularly, brush work and all kinds of carving. Its peculiar smoothness and evenness of grain make it suitable for many other uses. It has been used to some little extent in India for shuttles and bobbins, though its great suitability for wood-work of a more valuable character will, I hope, prevent such a use as this in the future.

Koko.

An incident which happened recently will serve to shew you what a strange want of appreciation is sometimes shewn by those who use timber. I went to a building owned by a large wood-working concern in London, and I found that the entrance doors, both outer and inner, were made of Andaman koko, which looked very well, though not in very good condition, and which, in my opinion, surpassed in general appearance any kind of walnut, including Italian walnut, which might have been used instead. Recognising the wood, I asked the proprietor, who has had great experience, of what the door was made, and he said, "Italian walnut." I found that he had purchased the timber more than 15 years ago under this description. Had I gone to him, or to any one else in a similar position, and suggested that koko should be used on its merits, I should have met with a more or less politely expressed refusal.

This timber is remarkable for its handsome colouring and strong figure; its standing qualities are excellent.

Pyinma.

Another of the magnificent timbers swept into obscurity under the baffling title of "jungle woods," and consequently almost entirely overlooked, is pyinma. It is probably a more valuable wood in its general qualities than any timber in the whole of the continent of North America, for example. In India, of course, it does not possess the same value as teak, as although it is partially proof against white ant, it is not wholly so. For Europe, I doubt whether its excellent qualities do not place it in almost as high a category as teak.

I have here some instrument cases made of pyinma. I think you will agree with me that they have as good an appearance as the black walnut or teak which is generally used, and I can assure you that in my opinion they will prove to be equally good, if not better, in wear. The first is a telephone magneto box, which demonstrates the suitability of the wood for corner locking. The next, a battery box with machine dove tail, shews the sharp and clean cut edges which can be obtained, and the third example, a bell push, illustrates the good turning qualities of the wood.

Its great reliability, coupled with excellent qualities of texture and grain, places it very high for decorative wood-work.

White Bombwe.

Another important wood is white bombwe, which is very strong and has a firm, hard and close texture. It should prove to be

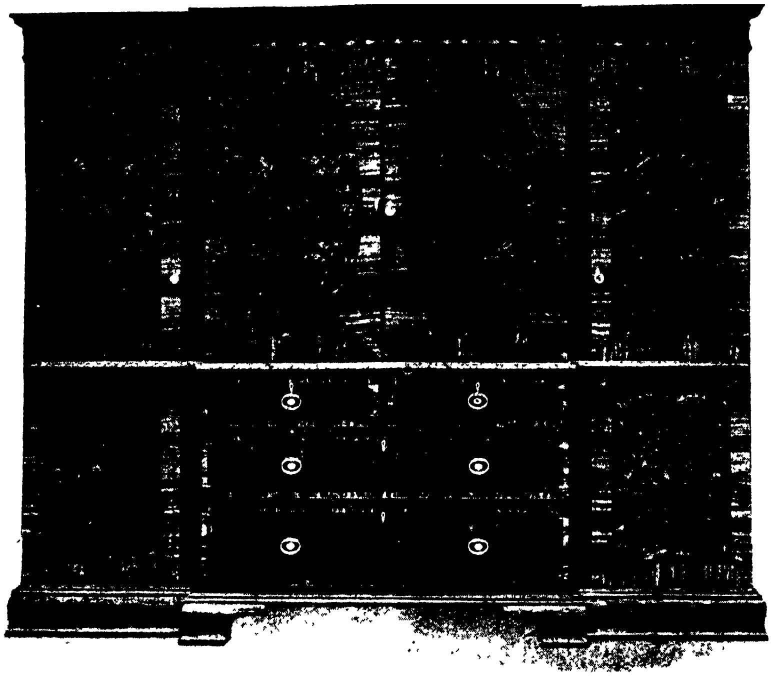

FIG. 6.—Wardrobe in Indian Black Walnut

exceedingly serviceable here, though in India there is scarcely any demand for it. Here I want to say again that it is wrong to assume that because an Indian wood is not used in India it cannot be used in this country. The chief factor which determines the use of a wood in India is its resistance to white ants, dry rot or other forms of decay. The prominence of teak in this resistance, coupled with its general availability, results in this timber practically holding the field against all others.

WHITE MAHOGANY.

Another of the cheaper woods is Indian white mahogany, a timber which a friend of mine recently described as one of the most useful of all woods for any kind of indoor work. It has a smooth, silky surface and is very easily worked; it is light in weight but is strong enough for any but constructional purposes. It is in every way a suitable wood for all fittings and fixtures in cabinet-making, joinery and ship-building.

Of the other woods of which there are specimen panels here for you to see, there is unfortunately no time to speak at length, though I might commend to your notice the coral-wood of the Andaman Islands, a reddish-golden, highly-figured wood which was known in France 70 years ago under the name, "bois de corail"; sissoo, which has been successfully used for fine cabinet work; thitka, which resembles Cuba mahogany; and a beautifully figured "curl" of Indian prima-vera. There is also a panel of teak in what is known as "fiddle-back" marking.

I suppose that I may be held to have been unduly enthusiastic on this subject, of which to-night I have but touched the fringe. If so, I must beg you to excuse me on the score of the deep interest I take in the matter and of the firmness of my belief that if the work is properly managed these timbers have a very great future before them in the markets of the world.

[The Society is indebted to Messrs. Macmillan & Co., Limited, for the loan of two of the illustrations (Figs. 2 and 5).]

MR. HANNAY, after reading the paper, said he had taken the liberty of adding a few words on his own account. The last time he visited that lecture room, which was built, he believed, for the Society by the Brothers Adam, it struck him what a splendid opportunity

was afforded by the lower portion of the walls for panelling in fine wood. It would harmonise with and add to the rich effect of the paintings above, and of the fine ceiling. Robert Adam was an innovator and a ready acceptei ot all new things that seemed to him good, and Thomas Chippendale before him, and of his time, was the same. He was satisfied that if those Indian woods had been introduced a century and a half or more ago, the best of them would have been eagerly taken up by those great men. Mr. Percy Macquoid, in his great work on furniture, had classed English woodworking periods as the age of oak, the age of walnut, the age of mahogany, and the age of satinwood, and they were now inaugurating a new period, the age of Indian woods. He suggested, with diffidence, and with hope, that that learned Society might fittingly join in and encourage the progressive movement by decorating the walls of its Hall in the manner suggested. The spirit of Robert Adam pervaded that place and neighbourhood, and he was certain that it would look on with approval.

Sir George Hart then exhibited a large number of lantern slides descriptive ot the paper, and explained them to the audience.

DISCUSSION.

The Chairman (Sir William Meyer), in opening the discussion, said it had been a very interesting and practical paper by one who was a complete master of his subject. They would all, he thought, concur in Mr. Howard's view that a proper forest policy should combine scientific treatment of the forests in such matters, for instance, as planting, conservation and felling, with commercial acumen in disposing of the products. Before he left India, it had been recognised that the Forest Department needed development on the commercial side, and, as Mr. Howard had told them, that proposition was emphasised by the Industries Commission. It was no disparagement to the admirable Forest Service to recognise that some of its officers, absorbed in the conservation of forests, were not fully alive to the necessity for finding advantageous markets for the products, and thereafter it would be necessary to lay greater stress on that side of the Department's activity. He did not think either that many of those who had had Indian experience would contest Mr. Howard's dictum that as the forests in India, now a magnificent asset, had been developed by Government enterprise and under Government control, that policy, the success of which had been fully demonstrated by actual results, should continue. But when it came to the disposal of the products, especially in distant countries, private enterprise could be advantageously utilised, and Mr. Howard's own activities afforded the best proof of that. He was sure that no direct Government agency could have done anything approaching what Mr. Howard had in the way of finding markets at home for Indian timbers, and the furniture and other objects that could be made from them. Mr. Howard had been constantly on the look out for such development, and the list he had given of the public bodies and companies who had been persuaded to utilise Indian timbers for railway carriages, panelling, flooring, furnishing, and so forth, evidenced his success. He believed that, as time went on and the virtues of Indian timbers became more fully recognised, there would be great developments in that direction; indeed, Mr. Hannay had already suggested one with which the Royal Society of Arts was greatly concerned, namely, that the fine Adam Room in which the meeting was being held should be panelled with Indian woods. Provincial Governments in India were now much more fully concerned with forest policy than they were prior to the political reforms lately introduced, and in the development of the industrial side of forestry full sympathy might be expected from Indian politicians, who had long emphasised the necessity for developing India's industrial resources. Old Indian as he was, the Empire Timber Exhibition, over which he had the pleasure of being escorted by Mr. Howard, was a revelation to him of the uses to which a number of their timbers, which as Mr. Howard had told them were not much esteemed or utilisable in India itself, could be put to here, and of the beautiful furniture, for example, that he had made therefrom. Before concluding, he desired to read a letter that had been received from an eminent Anglo-Indian (old style), Sir Louis Dane. Writing from Lyndhurst, he said:—

"I much regret that engagements here will prevent my being present at the lecture on the Timbers of India and Burma on 27th January. If the question of exploitation of the forests is to be debated I trust that the present urgent necessity for limiting the strength of Government establishments, and the very unfortunate results of former attempts to work the forests by direct Departmental Agency, will be remembered. In the Punjab and Kashmir the forests were practically unremunerative until they were developed by commercial agencies working under strict expert control."

That was an interesting expression of opinion, though personally he shared Mr. Howard's views rather than those of Sir Louis Dane.

Professor R. S. Troup, C.I.E., M.A., said that as the subject was being dealt with entirely from the commercial point of view he desired to mention that he was engaged for a good many years in trying to push Indian timbers both in India and in Burma. He then found the very greatest difficulty in getting private enterprise

to take up any new form of exploitation. Well known timbers like teak, sal, deodar and others were exploited to the utmost extent, and people were making such a lot of money out of them that it was almost hopeless to get any one to risk capital in trying to develop timbers which personally he knew were valuable, but which it took more convincing than his powers of persuasion were able to exercise to induce private enterprise to take up. He thought it was a wise move on the part of Government when they found an agent in this country who was in a position to push some of those lesser known timbers and to make such a very good business of it. Any one who went to the Timber Exhibition in London must have been impressed, whether he knew anything about Indian timbers or not, with the extraordinarily fine use to which the timbers were put for panelling, furniture, parquet flooring, etc. It was necessary, however, that a note of warning should be given in connection with one question dealing with the export of new timbers, namely, that there was sometimes a tendency to float quantities of timber on the market before the market was ready to absorb them. There was also a risk of large quantities of timbers which had made a name, as some of the Indian timbers were already doing, being put on the market by all and sundry without possibly a full appreciation of even the identity of the timber, and of other timbers possibly something like them, but not identically the same, being used. He knew of cases where harm had already been done in that way not only in India but elsewhere. The author had mentioned in his paper that the forest area of India was 250,000 square miles. That statement required a little qualification, because that area included an area of 141,000 square miles of what were termed unclassed forest, i.e., forests which had not been brought under systematic treatment. A considerable area of those unclassed forests would in time either be cleared for cultivation or abandoned as not worth working. The point was a minor one because the forest area of India, including Burma, was so vast that, even after meeting all their own requirements, India, Burma and the Andaman Islands were in a position to export a large quantity of timber.

Sir Charles H. Armstrong said he was an enthusiast with regard to the future of Indian timbers in this country. While he was not an expert on the Indian timber question, he had always been a great believer in Burma teak, and he knew as a fact that many of the woods which were produced in India were very suitable for decorative purposes and also for railway work in this country. He was glad to hear the Chairman say that his offices were to be decorated with Indian woods, and he felt sure the High Commissioner could be trusted to advertise them to the best of his ability. When he came home in 1914, after 30 years' residence in India, he brought with him all his furniture which had been made in Bombay of the very best Burma teak, and he would be very pleased to show it to any of the Fellows of the Society who cared to call upon him at Guildford. Nearly everybody who came into the house admired his furniture and asked him where he obtained it. Teak took a beautiful polish, and in his opinion it was one of the most satisfactory woods for furniture making. It might be a little heavy, but at the same time it was very substantial. With regard to the question of the cost of bringing woods from India and Burma to this country, there was no doubt that the expense of bringing some of them down to the seaboard was very considerable, and he imagined that would take away a great deal of the profit. Once, however, they had been brought to the sea, the freight ought not to be any great deterrent. He did not believe that the freight and shipping charges from India would be very much greater than on the so-called mahoganies, walnut woods and oaks which were imported. The people of this country were very conservative, and it was very difficult to induce them to use woods other than those to which they had always been accustomed, but he felt sure that, if Indian woods were only properly advertised, in the course of time the demand for them would grow. But it had to be recognised that it was a very difficult trade for private enterprise to take up. He entirely agreed with Professor Troup that too much of any one timber of a new quality should not be put on the market at once. The best plan to adopt was to put small quantities on the market to be sold at prices which the market could afford, and gradually to force the market up to a paying level. That might possibly take years, but when once the trade had been established he was certain it would continue satisfactorily.

Sir George S. Hart, K.B.E., C.I.E., said it was stated in the paper that an appreciation of the needs and difficulties of the industrial world must guide the trend of scientific research. None of them would be so stupid as to deny the truth of that assertion for a moment. The point he wished to urge was that, with regard to the science of forestry, industry must not expect too much. The forester had to think in half-centuries, and his work was planned for the benefit of posterity. He could not for an instant swerve from the paramount necessity of maintaining his forests in such a condition that their output would be assured in perpetuity, and, in so far as that might be possible, increased steadily. America, Canada, and, he believed, Australia also, had had practical experience of the grave results which must follow if that policy was not enforced. India as a whole, he was thankful to say, had had no such experience, for the Forest Service, though

only some 65 years old, was established in time to prevent any general destruction of the forests. For that reason he regarded the future for Indian timbers as particularly hopeful; and he thought they could be certain that as long as British influence on Indian policy was maintained the upkeep of India's vast and valuable forest estate might be regarded as assured. Given reasonable facilities for exploitation, the question was not, therefore, whether the supply of Indian timbers could be maintained, but whether markets to absorb the supply could be found. The author had expressed himself in favour of exploitation by Government Agency as compared with private enterprise; at any rate, with regard to the work to be done in introducing little known timbers to the markets of the world. That was, perhaps, rather a controversial question, and one naturally desired to avoid controversy as much as possible: also he had spent many of the earlier years of his service dealing, among other things, with departmental timber work in all its aspects: the actual exploitation, the transport from the hills to the plains and the business end in the timber depots, so that he might, perhaps, be somewhat prejudiced in favour of the system he knew so well. On the other hand, he had seen many instances of forest work under private enterprise from one end of India to the other, and, speaking generally, and from the point of view of the forest officer only, he did not like it. Obviously it was the system to work on under certain conditions; *i e.*, where the conditions of extraction and transport were easy, where markets were fairly close at hand and assured, and where the trees to be removed could be marked and sold annually under strict regulation, notably with regard to the completion of the removal from particular areas. But where extraction and transport were difficult, markets not assured, and long term contracts with easy conditions with regard to the payment of royalties, the execution of the various works and the clearing of the areas, had to be offered in order to induce purchasers to come forward; then he knew that in the interests of the forests, private enterprise should only be called in, in India, and he included Burma, where for some reason or other departmental work was impossible. It was to be noted that he referred only to the regular forest work, that was to say, to the exploitation and transport of the produce to timber depots in the principal markets, or even to the nearest main line of rail, coupled with such preliminary conversion as might be necessary. Once that was completed and the felling areas cleared so that regeneration operations could be taken in hand at the proper time, private enterprise for the final conversion and marketing of the produce should be brought in: but it should be brought in on terms which would yield a fair return to both parties and not leave Government with the very low share which it had so often received in the past. He did not wish any one to infer that he thought the big timber trading firms in India and Burma had deliberately treated Government badly. They had not, and had he been running a timber firm, or working for one, under the agreements they were fortunate enough to receive from Government, he would have done exactly as they had. Their business was to make as much for their shareholders as they could, subject to complying with the terms of their contracts, and naturally they did nothing beyond the terms unless they thought it advisable in order to keep Government in a good temper and ensure the renewal of their leases. They could not be expected to spend money on making a really good road which might be useful in working another area later on, possibly by one of their competitors, when a rough track would serve their purpose; or, again, to go to extra expense in order to clear a forest before they needed to do so. If not clearing it meant a lot of damage to young growth, or much extra expense and work on regeneration, so much the worse for the forest officers whose job it was to attend to those things. One of the objections often urged against departmental working was that it prevented the forest officers from attending to their sylviculture. To a considerable extent that was true in the days before the war; but that reproach was now removed, as the Forest Service now had a branch of forest engineers, specially trained in up-to-date means of exploitation and transport, which would take over all work of that kind and leave the regular forest officers free to attend to their legitimate duties. In his opinion, the Governments of India and Burma had reason to be very grateful to the author for the work he had done in connection with Indian timbers. Without that work few of the timbers mentioned in the paper would have been heard of in England to-day. Reference was made in the paper to the work in Indian timbers carried out in Messrs. Francis Peek and Co.'s building in Eastcheap. He was taken to see that building a few days ago, and he really did not think that he had ever seen more delightful timber work. In particular, the laurel wood and gurjun panelling in the Board room and the door of that room, laurel wood on the inside and padauk on the outside, were strikingly beautiful and showed what could be done with those woods under skilled supervision.

Mr. J. W. Kitchin, O.B.E., said the chief impression left on his mind by the paper was the vast asset that India possessed in her timber, and it was quite clear that the country appreciated that fact because she had a splendid body of forestry officers to look after it. If means could be adopted of prolonging the life of timber, the object of the author, who had written his paper from a commercial and

practical point of view, would, he thought, be furthered. The trees of India, apparently, could be divided into two divisions, the first containing valuable and durable trees, which were known and sought after, and the second containing inferior trees, but among which there might be valuable trees also. There were 37,000 miles of railway in India, and the Railway Departments apparently were the biggest consumers of timber in the country, drawing their supply principally from the first division. If something could be done to enable those consumers to utilise timbers of the second division treated in such a way that it lasted longer than would naturally be the case the object desired by the author would be attained, namely, the wood would be used to the best advantage of the country. He greatly admired the way in which the economic side of the question had been dealt with at Dehra Dun, where for ten years past the subject of how best to treat timber in order to prolong its life had been under consideration. Coal tar, creosote products, insecticides and so forth had been tried, and a recommendation had been made that Powellizing should be extensively tried in India, in the same way that it had in Australia. If that recommendation was adopted India would benefit, the idea being to utilise some of the timbers of the inferior class. As an example of what had been done, 800 or 900 "chir" sleepers which had undergone the Powellizing process were laid down in a place where ordinarily the untreated timber lasted two years. After six years only one of the sleepers had been attacked by white ants, and less than six sleepers had to be rejected, so that the extension of the life of the timber was three-fold. The same sleepers seen again nine years after they were put down, or four-and-a-half times the life of the untreated timber, showed 70 per cent. of them still in place, 30 per cent. having to be rejected. The question of the antiseptic treatment of timber seemed to him a very important one for the economic success of India, because if it was possible to conserve Indian timber and use in the country, by means of the process referred to, timber which it was difficult to use at present, the more valuable and better timber would be set free for export to the world. The Powellizing process produced in less than a day what Nature took many years to produce, and by its adoption timbers of India imported into this country in a green state could be converted into high-class furniture within a few weeks of the time they were landed at the docks.

MR. E. M. HUGHMAN said that, as a large purchaser of Burma teak in India, he had been much struck with the figures given of the value of imports into England of Indian and Burma wood. Those figures showed that 94 per cent. was Burma teak and only 6 per cent. of Indian wood. Practically the only wood that could be used in India for ship-building, furniture, and domestic purposes was the best Burma teak. The decorative wood of India was very good for export, but of very little use in India itself. Personally he would rather see 94 per cent. of Indian wood imported into England, which would leave India free to make use of the Burma teak wood. He was perfectly certain that India and Burma could absorb all the teak wood that could be produced, and it would also keep the prices at a more reasonable figure. During the war very great difficulty was experienced in obtaining Burma teak for building wooden vessels; the price rose from about 40 rupees to 220 rupees a ton, and the difficulties of getting teak from Burma to Bombay and Calcutta were very great owing to shortage of shipping. Speaking as one engaged in trade in India, and from the point of view of the benefit of the people there, he thought it would be very much better to develop the beautiful woods of India which could be used very much better for English purposes, and leave Burma teak wood to those in India who required it so much.

MR. F. H. FRANCE said he wished to speak on behalf of the class that had hitherto not been represented in the discussion, namely, private enterprise, which was still the villain of the piece. The Forest Department, which had done excellent work for a long time and was looked upon as the hero of the piece, had thought commerce was one of the things it ought to leave alone before the author appeared upon the scene. Professor Troup and Sir George Hart had stated that private enterprise had not shown itself sufficiently active in the matter of introducing Indian woods which were undoubtedly of great value. His reply to that was, what had the Government done? Personally, he knew Burma fairly well, but he did not know of any single forest in Burma in connection with which the Government expended a single rupee on junglewood extraction; the whole business was done by private enterprise. When Government desired timber to be extracted from the forests they gave out licences or leases, including lately leases to the Burmese. Of course, every nation had the right to work its own possessions, but he thought time would show that the Burmese could not work an organisation on the same scale as the big firms. As the Government had done nothing in the way of extracting timbers from the forests by Government enterprise, it naturally fell to the private firms to do so, but what were the inducements at present? There were no markets; the markets were in course of creation; but it was up to the Government to show that private enterprise was at fault in the sense that it had not done anything. Private enterprise in one particular case with which he was acquainted

had taken up a lease of forests containing jungle woods and was prepared to put down £100,000 for making the railways and building the mills on the spot. He desired to use the argument, what would some people think if the Forestry Department said that it was prepared to spend £100,000 on a small area of 50 square miles? He ventured to say it would take a very great deal of consideration indeed; in fact, it would have to go on being debated years and years before anything was done If the Government were prepared to come forward and put down £100,000 to work an area of 50 square miles, then he would begin to believe that the Government had real faith in junglewoods, but until they did so he could not but hold a different opinion. The Government were quite prepared to work the very pick of the teak forests in Burma for which there was a market, but when it came to the other forests they wanted somebody else to pick the chestnuts out of the fire for them All trades had their slumps, and at the present moment the teak trade was probably at the bottom. Nevertheless, the Government were simply throwing thousands of tons of teak on to the market irrespective of the consequences Was that an inducement to a private firm to spend £100,000 to work a new proposition? Personally, it did not seem to him the way to encourage private enterprise to take risks in other markets. The Forest Department was an excellent body of men who knew their work thoroughly, and who had done and always would do very useful work in conservation, but when it came to utilisation he was not at all sure that all that had been said about private enterprise could be justified Anyhow, if the Government really thought that they could work better than private enterprise they now had the opportunity of showing what they could do in the case of the Indian jungle woods Much had been heard of their value, and it only remained for the Government to act

Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., M.P., proposed a vote of thanks to Mr. Howard for his valuable paper, to Mr. Hannay for reading it, and to Sir George Hart for describing the illustrations. He also, on behalf of the Indian Committee, thanked Sir William Meyer for taking the chair. Sir Charles Yate said he hoped it would be realised in England that woods for which there might be a considerable demand in the home markets were, as Mr. Howard had said, in small demand in India. In that way England ought to be able to obtain these woods at a price below their intrinsic value, which would be advantageous to the buyer in England, and thus help to their ready sale. He was glad to hear the statement in the paper that the author had been able, when in India, to lay the foundations of a scheme whereby it would be possible to have direct shipment of timber from Indian and Burmese ports to England. The Indian Forest Service was now a very fine one indeed. That Service previously received its training in France or Germany, but it now trained its own men in India and in Burma He hoped a good and efficient Forestry Service would be properly developed throughout the Dominions, the Crown Colonies and also in Great Britain, as it was essential that forestry should be taken up as a practical question in all portions of the Empire. It was only, however, by the help of Government initiation and exploitation that Indian woods could be brought into use in England, and he sincerely hoped that something more would be obtained from the Government of India than what the Chairman had described as full sympathy. Work was required by the Government of India to start the industry and to develop the trade between India and England, and he was sure everyone present looked to the High Commissioner to establish that trade on a firm and substantial basis

The Chairman said that he would do his best.

Mr. W. Coldstream seconded the motion, which was carried unanimously.

Mr W. Coldstream, late I.C.S., writes:—

In seconding the vote of thanks, it was too late for me to make any remarks, and as requested, I now write the few words I wished to say. It would have been a decided advantage, both to the public and to experts if the scientific (Latin) names had been given in the case of each species of tree named I may say that confusion may well arise with reference to some, for instance, boxwood, which was mentioned. The wood, which the Forest Department has named Indian boxwood, is said not to be of the genus *buxus*; but there is a very fine wood which is called boxwood in the north of India (shamshad or chikni), which has been identified as *Buxus sempervirens* (Stewart's "Punjab Plants"). The tun was mentioned—a very valuable wood, but our Punjabi shisham, or tali *Dalbergia sissoo*, did not hold one of the places of honour, which I humbly think it should have done, as it is such a very valuable wood. Both the shisham and the tun are splendid for furniture, and (the shisham especially) for many other economic purposes. Sir Charles Armstrong gave us a kind invitation to view his furniture of Indian woods I should be very glad to show my specimens of furniture made of shisham and Punjab walnut and small articles of boxwood and ebony to any who are interested. Of course, the paper could include but a small fraction of the vast subject, and the names of but a few woods could be given; but besides those above mentioned the various species of Eucalyptus have become so im-

portant in India that it would be interesting to hear something about them, and what species of this genus produce woods which promise to be really useful as timber. Their rate of growth is enormous. I hope I may be excused for venturing these remarks. I am much interested in the subject, for I saw the Forest Department formed in North India under Lord Canning, and the first Lord Elgin, and was present at the first (as I believe) Forest Conference in Simla in 1875, at which I had the honour of reading a paper on district arboriculture; and as a frequent wanderer in the magnificent forests of the Simla district (which were beautifully illustrated and described by Sir George Hart) and a quondam resident in the beautiful forest hut at Nachar, which we saw on the screen, I should like to mention the names of Cleghorn, Brandis, and Stewart, who first described this vast and valuable forest area in the early sixties. As hard-working pioneers of the Department, and its earliest administrators in North India, I would like to record their names here. It is earnestly to be hoped that the Diarchy will deal wisely and cautiously with the vast property of the Indian Forests, and with the Department of able men who have been selected as its officers. I very heartily associate myself with the proposal to give private enterprise the utmost scope consistent with the safety of the forests. Great destruction was wrought in the Forests of the Simla district in earlier years before proper conservancy was introduced.

The practical issue of the paper was well voiced in the speech of Sir Charles Yate, and we would all join very earnestly in encouraging the action of the High Commissioner in carrying forward the exploitation of India's useful woods, and for their speedy introduction to the markets of Europe and America.

MR. G. M. RYAN, F.L.S., late Indian Forest Service, writes :—

Apropos of what was said by Mr. Howard in his valuable paper in advocacy of Government agency as the best means of exploitation of the forests under the Government of India, it may not be uninteresting to record that as far back as 1890-1893 this question of private *versus* departmental enterprise came up for consideration in connection with the working of the forests in Sind, a province included within the limits of the Bombay Presidency and about the size of England and Wales, containing approximately 1,200 square miles of forest. The question was decided in favour of the former method, *i.e.*, private enterprise, and adopted, with results which the experience of time (over 25 years) has demonstrated to be a great improvement over the latter method. The subject is too long to be discussed here; suffice it to say that as I initiated this change of system into Sind, I trust it will not be considered presumption on my part if it is asserted that there appear to be certain parts of India where a similar alteration in forest policy could probably be inaugurated with advantage not only to the Forest Department and timber merchants, but to the State generally. In Sind for example, the change in policy, which my successor in office continued and extended with marked ability all over the Province, effected an almost immediate annual saving to Government of about three lakhs of rupees, without in the least degree impairing efficiency. In a report submitted to the Secretary of State for India in 1920 on the high commercial and politico-economic importance of the forests of Sind, this fact was emphasised and the suggestion was thrown out that private agency under the circumstances, in regard to forest exploitation might be introduced or given a trial, at any rate, in certain localities in India where it did not exist. One speaker at the meeting (Mr. J. W. Kitchin) advocated the Powellizing of some of the Indian timbers. This is a question which also was discussed many years ago (in 1905-06) in the Bombay Presidency, and Sir Henry Procter, C.B.E., with commendable foresight and enterprise, formed a syndicate in India to treat Indian and imported timbers in this way. He has spent over £25,000, as far as is understood, in his efforts to get Powellized wood of certain Indian and other woods accepted, especially for railway sleepers, but so far apparently not with much success, although the Forest Economist at Dehra Dun (Mr. Pearson) has reported fully and very favourably on the method of Powellization. All this shows what private agency can do and is prepared to do in India.

MR. F. J. WARING, C.M.G., M.Inst.C.E., writes :—

I consider this to be a most interesting and valuable paper, but it might be rendered even more valuable if the author could give the botanical names of the timbers he specially mentions. I had the privilege of visiting the Empire Exhibition of Timber in 1920, and was struck with the beauty of many of the cabinet woods there shewn, and am glad to learn from the particulars given in the paper that, largely I suppose owing to the publicity afforded by that Exhibition, practical use has been made of many of these woods. During 1920, a year certainly of inflated prices, wood and timber to the value of £82,145,214 was imported into the United Kingdom the whole of which, except timber to the value of £12,495,619 from Canada and teak to the value of £1,406,550 from India, came from foreign countries. The author confines himself principally to cabinet timbers, but others are worthy of attention. In view of the fact that the consumption of timber by the world is largely in excess of its natural

production, the question of timber supply in the future is a problem the gravity of which cannot be exaggerated, and demands the most serious attention. It is possible that some of the Indian and Burmese woods mentioned by the author might be grown in other tropical portions of the Empire. It is also perhaps possible that some varieties of the Eucalyptus, especially the Jarrah (*E. marginata*) and Karri (*E. diversicolor*) Western Australian timbers, of much value for railway sleepers and general construction work, might find a suitable habitat in the drier parts of India, such as Sind, the Punjab and Central India, or in parts of South Africa.

The Blue Gum (*E globulus*), another Australian timber, is quick growing and readily adapts itself to the far different climate of the hilly districts of Ceylon, where the rainfall in contrast with that of Australia is heavy and where at altitudes of from 3,000 to 6,000 feet above sea level it grows well without special care, and it is perhaps possible that the Jarrah and Karri might possess equal adaptability to difference of climate. It would be interesting to know whether this experiment has been tried.

NOTES ON BOOKS.

ENGINEERING STEELS. An exposition of the Properties of Steel, for Engineers and Users. By Leslie Aitchison. London: Macdonald and Evans. 1921. 25s. net.

The extent of the practical service which Mr. Aitchison's book may render to the Engineer will be at once evident to anyone turning over the pages, which in all amount to XXXII + 396, but 47 inset plates at the end of the book are included in the paging to bring all of the figures conveniently within the scope of the index.

Characteristic properties of steel as bearing on its suitability for the manifold purposes to which it is now applied are set forth in the clearest manner, while the various methods by which the many types of industrial steel are produced are touched upon lightly, yet sufficiently; this being what the Engineer or user requires in selecting qualities suitable for specific purposes.

Thus it will be understood Mr. Aitchison's book is a work of details, many being minute and at first seem almost trivial in importance; they are not so, however, in fact; as a fine adaptation of quality of steel to use was one of the leading technical issues in the great war, the present work is largely a peace issue of the war.

A work consisting mainly of minute detail requires the utmost care and skill in arrangement, classification, and indexing, and Mr. Aitchison is to be complimented on the success with which he has overcome the many difficulties incidental to good arrangement. He makes it quite clear that he regards adaptation or conformity between quality and use of steel as a leading matter in progress and he says "the steel of the watchmaker's drill is of no use for the rails of a locomotive track, neither is the steel of the rifle barrel good for drilling armour."

The concise chapters, treating of productive methods and the stages of progress, trace modern differentiations in quality to the pioneer work of Huntsman in 1742. Huntsman was a watchmaker, who then adopted the method of fusion in order to produce homogeneous steel for springs. Valuable as the crucible method may be for experimenting and for preparing extra fine steels for special uses, it gives place to the electric furnace, Bessemer converters and open hearth methods for production on a large scale.

Large-scale working, however, despite its many economies and advantages has special defects and troubles which are more or less inherent to the larger scale of work. The large ingots in cooling develop varieties of crystallistion in the different parts (p. 26), and the forging or working of the ingots distorts not only the individual crystal but also the groups. Although it may be thought that the crystals can by forging lose their identity and perfectly merge into each other, this is not always the case, perhaps by reason of an outer skin of non-metallic impurity around the crystals. In this way, and otherwise, we often have a lack of homogeneous structure as shown in many diagrams (Figs. 14, 17, and others). The sectional photograph, Fig. 101, and the text p. 295, show us how many latent dangers may become active under special conditions of working; cracks arising in the sharp angles of a castellated shaft, as shewn.

All the essentials relating to the workshop qualities of steels are treated of in a remarkably thorough and satisfactory manner

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OILS, FATS, AND FUELS. By Thomas Hull. London: Blackie and Son, Ltd. 1921. 3s. 6d. net.

This miniature handbook (144 small octavo pages) is according to the preface, intended for the use of Students in day and evening continuation schools.

Although calculated to awaken interest in the subjects treated of, and to lead the student to larger works, there is rather a lack of such exactness in chemical details as appear desirable in an educational book, and as an example we may refer to p. 5 and p. 70, where the relationship of glycerine to the fatty acids is considered but with neglect of the water factor which is involved in this relation. On each of the pages mentioned above is a statement, in the form of an equation, which involves neglect

of the water factor: hence incorrect, but possibly considered good enough for a pupil in a primary school, who may learn more in after stages. A brief mention of the Wilson method (or Tilghman method) of hydrolysing fat with superheated steam would have made a correct understanding of the matter easy; moreover, this method was for about half-a-century (1854 to 1904) approximately the leading or perhaps only, method by which pure glycerine (Price's) was manufactured. A concise account, but complete in essentials, of this remarkable process will be found on p. 274 of Part III., Miller's Elements of Chemistry, 1862, edition.

It would be grossly unfair to close our review at this point, as the notable merits of the book far outweigh any omissions or faults which may be discoverable. The style is lucid, the order, sequence and system are good and to a casual reader the interest is likely to be maintained. In short, a copy may constitute a remarkably useful present to a schoolboy, as leading to interest in subjects otherwise outside his usual range of thought.

The following may be mentioned. Illustrations in text showing laboratory device for determining melting points, the digester for rendering fats, the hydraulic oil-press, the laboratory fat extractor by solvent, the coco nut in aspect and section with its thick outer covering of coire, map of Scottish oil fields followed by a diagrammatic section of the shale-retort now in use, a charcoal meiler in section with turf covering, a modern coke oven, oil furnace for steam boiler and a modern spray burner or atomizer with double air stream

Inset plates show the forest gathering of turpentine, oil wells at Los Angeles, stills for petroleum, oil reservoirs and barge, oil tanker at sea, Port Sunlight 60-ton soap pan with accessories, and a Tyneside plant for condensing coke oven products

Blue Printing and Modern Plan-Copying. By B. J. Hall, M.I.Mech.E. London: Sir Isaac Pitman and Sons, Ltd. 1921. 6s. net.

Here we have a text book of photographic contact printing and kindred modes of reproduction as far as such work is incidental to office routine, or to the routine of industrial establishments, as for example engineering works where plan-copying at high speed is often an important feature.

The book drifts outside the strict range of contact printing, where this is desirable, and treats of the use of a special set camera for reproducing office matter.

Details are given mainly with respect to appliances for rapid and convenient work, and it is generally assumed that the requisite sensitive materials as also chemical preparations will be purchased ready for use, as far as this is practicable; hence Mr. Hall's book is not to be regarded as a treatise on the photographic methods in their inner chemical aspects. Further there is no concealment as to the fact that Messrs. B. J. Hall and Co., supply appliances and materials; their advertisement being prominent at the end of the book.

In its scope as defined, the book is thorough and satisfactory and it embodies many hints as to miscellaneous matters, as for example the making of type-written sheets which will serve as originals in photographic printing.

Relativity, The Electron Theory and Gravitation. By E. Cunningham. London: Longmans, Green and Co. 1921. 10s. 6d. net.

Professor Cunningham presents to his readers a sequent and lucid account of Einstein's concepts as to relativity, and mentions a slight but important, change in usage as to terms (p. 2 and 8), by which Einstein's "principle of relativity" is now more precisely termed "the special principle of relativity," and it is based on the view that physical experiments will not serve for determining the absolute velocity of a body through space.

We may perhaps be allowed to preface our notice by some partially applicable parallels. Let us suppose a person standing at the end of a platform when an express train passes at full speed, with the whistle sounding.

Although the speed of the train in relation to our bystander may be regarded as uniform, and the note of the whistle will be uniform to the engine driver, our bystander on the platform may notice a change from a higher to a lower pitch or note at the instant that the sounding whistle passes in front of him; the approach of the train increases the frequency with which the waves of sound reach our observer, and the contrary effect (diminished frequency) gives him a sense of a lower note the instant that the whistle has passed. An intensified form of this apparent or relative change in pitch may be noticed by a person in a train which meets another train of which the whistle is sounding.

In a similar way light coming from a source travelling towards a position is made higher in pitch as far as this position is concerned, and *vice versa* (Doppler effect); a fact which enables us to estimate the speed at which certain stars are moving in relation to the earth, the datum for observation and measurement being, for example, the shift of the F line in the spectrum.

The above-mentioned instance in its two forms (as to sound and as to light) is an example of the many cases in which a phenomenon may vary considerably according to the relation of the observer to the source.

We may put the case otherwise and far more generally by saying that the physical manifestations of the ens, are subject to, or implicated in the predicaments (categories); ten by the count of Aristotle, or four (with qualifications)

by Kant's system; but relation has place in both lists.

As bearings on datum-places in intellectual progress let us now take three periods of astronomical study and result. About 200 years before Christ, Eratosthenes, who had charge of the Library at Alexandria, having evidently learned what was then the modern view of the heavenly motions, made measurements with the best instruments at his disposal. These were only divided to arcs of one-sixth of a degree; but notwithstanding this his measurements confirmed the conjectures of Hipparchus and others as to the obliquity of the ecliptic, though his observations were disturbed as he made no correction for the greater refraction of light at the winter solstice. Eratosthenes also made measurements as to the circumference of the earth and although the geometry of his method was correct there were disturbing factors, and some data were not exact.

During the long interval from Eratosthenes to Newton, methods and knowledge advanced much, so Newton was able, in his Principia, to promulgate such incontrovertible data as to the relation of gravitation to orbital movement, that the fundamentals, as touching the question of Galileo's "heresy", were settled for ever. We must not, however, forget that Newton laid one of the foundations on which the next great step was to be laid, as without modern developments of Newton's studies as to fluxions that notable stage in progress to which we are being led by Einstein and his followers could not be developed.

At the outset Professor Cunningham makes it evident that the purely metaphysical aspect as to the infinities (space and time) is put aside or is outside the question. "Physical Theory has nothing to do with absolute space" he says definitely (p. 2), but the space with which physical theory deals is "one aspect of the relations which have been observed between the phenomena with which physical theory is concerned."

There may be many aspects of such relations, and each aspect may be in relation to one particular status of reference; the status of reference first suggesting itself for light being the ether. For the present purpose one must not regard the ether as an attenuated form of matter, but as a medium which can penetrate matter and be undisturbed by the passage of matter through it. This concept of the ether, as being stagnant, led to endeavours to trace such physical effects as might, in theory, be expected by the motion of bodies through it: but with no very definite success, doubt being alternately directed towards the experiments and the finer borderings of the stagnancy concept. Great difficulties arise, and as all astronomical and gravitational data are involved in observations by rays of light, there is not only the question of any gravitational bending but also the question of the Doppler effect, already mentioned in our introductory notes, and further treated of by Professor Cunningham (p. 42).

In studies of this nature the effects due to space and time become so interwoven that Minkowski has been led to the view that space and time are two aspects of a single reality (pp. 6, 72, 75) and in developing this idea he pictures a four-dimensional status in which space and time become space-time; a fourth dimension, or structure-element.

Arago's contention of 1818 that if glass moves towards the light the relative velocity of the light at entering must be greater than if the glass is at rest, is considered at some length, with conjectures as to why Arago did not realise the experimental confirmation which he expected; and also the culmination in Fizeau's experiment as to the effect of a stream of water on light The recent aspects of Fizeau's experiment are figured and described in relation to the special principle of relativity, and there is a profound study of Weyl's theory of electricity and the electric theory of matter, also the deflection of light in a gravitational field, now confirmed by observations of the perihelion of mercury and in less degree by the work in relation to the recent solar eclipse.

Professor Cunningham is to be congratulated at the satisfactory way in which he carries out his intention of producing a book which shall be of service to the general reader and the experimental physicist.

GENERAL NOTE.

Giant Grasses for Paper Making.—Hitherto tropical and sub-tropical countries have relied mainly for their supplies of paper-making materials on the forests of the northern temperate regions. Wood pulp, prepared from spruce and other timbers in the United States, Canada and Scandinavia is, for example, imported into India and Australia for the manufacture of the cheaper kinds of paper, whilst countries, such as those of tropical Africa, in which manufacturing industries are in a less advanced state, import practically all their paper ready-made. In almost all these countries, however, there are native products which could be used for making paper, and in some cases a survey of the materials available is being undertaken. Bamboos appear to be the most promising source of paper-pulp in India and the Far East, whilst in other countries large grasses, many of which are similar to bamboos in appearance, exist over extensive areas and could be used for the same purpose. In the current number of the Bulletin of the Imperial Institute, a comprehensive account is given of these giant grasses. Preliminary trials have proved that many of them give a satisfactory yield

of pulp, which produces good paper. In the case of the so-called elephant grass of eastern tropical Africa, these results have been confirmed by large-scale trials and the material has been used in Uganda for Government printing paper, which is of excellent quality. Such grasses, owing to their bulk, could not be exported to Europe at a profit, but it is suggested that they might be employed locally for paper making or for conversion into pulp for export.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, FEBRUARY 20..Health, People's League of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C, 6 p.m. Dr. R. S. Rows, "Association of Ideas, Recognition and Memory."

Geographical Society, 131, New Bond Street, W., 8.30 p.m. Mr. A. F. R. Wollaston, "Natural History of South-Western Tibet."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Mr W. Dale, "Christianity in Roman Britain."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. A. J. Davis, "The Internal Decoration of Ocean Liners."

East India Association, Caxton Hall, Westminster, S.W. ,3.30 p.m. Mr. A. T. Arnall, "Hydro-Electric Power in India."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p m. (informal meeting). Discussion on "The Emergency Use of Oil Fuel during the Recent Coal Strike." (Liverpool Centre) The University, Liverpool, 7 p.m. Dr. S. S. Richardson, "An Oscillograph Investigation of the Gulstad Relay."

TUESDAY, FEBRUARY 21..Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Sir Arthur Keith, "Anthropology of the British Empire." (Lecture 1.)

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p m. M. M. Thiery, "La Comédie de Moeurs et le théatre d'Alexandre Dumas, fils."

Marine Engineers, 85, The Minories, E., 6.30 p.m. Mr. D. R. Hutchison, "Types of Large Marine Oil Engines."

University of London, at the Imperial College, Royal School of Mines, South Kensington, S.W., 5.30 p m. Colonel N. T. Belaiew, "The Crystallisation of Metals" (Lecture I.) At the London School of Economics, Houghton Street, Aldwych, W.C., 6 p.m. Sir Joseph Stamp, "The Administrative Factor in Government." (Lecture II)

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. Meeting in commemoration of the first meeting of the Society of Telegraph Engineers in 1872. To be continued in Wednesday and Thursday. (North-Western Section), 17, Albert Square, Manchester, 7 p.m. Messrs. Haden and Whysall, "The Utilization of Waste Heat from Electrical Generating Stations."

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Colonel T. C. Hodson, "The Primitive Culture of India." (Lecture V.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. G. A. Booth, "Natural History Photography."

Automobile Engineers, Institution of, at the Chamber of Commerce, New Street, Birmingham, 7 p.m. Dr. Ormandy and Mr. E. C. Craven, "The Physical Properties of Motor Fuels—a Discussion in their bearing on the Motor Industry."

Educational Needlecraft Association, Essex Hall, Strand, W.C., 7.30 p.m. Mrs. L. Glasier Foster, "The Importance of the School Sewing Lesson."

WEDNESDAY, FEBRUARY 22..Massage and Medical Gymnastics, Society of, at the ROYAL SOCIETY of ARTS, John Street, Adelphi, W.C., 6 p.m. Dr. Gladstone, "The Structure and Functions of Muscle."

University of London, at the London School of Medicine for Women, Hunter Street, W.C., 5 p.m. Dr. H. H. Dale, "Some Recent Developments in Pharmacology." (Lecture I.)

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. (1) Dr. C. W. Andrews, "Description of a New Plesiosaur from the Wealden Clay of Sussex." (2) Mr. T. Landell-Mills, "The Carboniferous Rocks of the Deer Lake District of Newfoundland." With Notes on the Petrography by Dr. A. Gilligan, D.S. and on the Palæontology by Dr. A. S. Woodward.

Literature, Royal Society of, 2 Bloomsbury Square, W.C., 5 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. C. O. Blagden, "Matriarchy in the Malay Peninsular."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Mr. P. C. Varner-Jones, "Industrial Colonies and Village Settlements for the Consumptive."

Industrial League Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. R. Horniman, "A Proposed Solution to the Transport Problem."

Electrical Engineers, Institution of (South-Midland Section), The University, Birmingham, 7 p.m. Mr. F. P. Whitaker, "Rotary Converters, with Special Reference to Railway Electrification."

THURSDAY, FEBRUARY 23 .. Aeronautical Engineers, Institution of, at the ROYAL SOCIETY of ARTS, John Street, Adelphi, W C., 7.30 p.m Lt.-Col. Moore-Brabazon, Presidential Address, "The Early Days of Aviation."

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. H. K. Dysin, "What is the Use of the Modular Ratio?"

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. A. E. Hayes, "Phonoscript."

Mechanical Engineers, Institution of (North-Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m.

Automobile Engineers, Institution of, Masonic Hall, Coventry, 7.45 p.m. Mr. E. L. Bass, "Engine Lubrication."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. Mlle. M. Vigoureux, "Hippolyte Flandrin et la Peinture Religieuse."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. G. Perkin, "Dyeing—Ancient and Modern" (Lecture II.)

Brewing, Institute of, (Yorkshire and North-Eastern Section), Leeds. Dr. E. J. Russell, "Barley—its Composition and Growth."

Dyers and Colourists, Society of (Yorkshire Junior Section), Leeds. Dr. S. A. Shorter, "A Descriptive Address on Colloids."

FRIDAY, FEBRUARY 24..Technical Inspection Association, at the ROYAL SOCIETY of ARTS, John Street, Adelphi, W.C, 7.30 p.m.

Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.

Auctioneers' and Estate Agents' Institute, 34, Russell Square, W.C., 11.30 a.m. Conference of Agricultural Members, 2.30 p.m. Mr. E. Whittendale, "Farm Valuations."

Royal Institution, Albemarle Street, W., 9 p.m. Prof. J. Joly, "The Age of the Earth."

Dyers and Colourists, Society of (Scottish Section), Glasgow. Dr. H. H. Hodgson, "Suggestions towards a Research Policy."

SATURDAY, FEBRUARY 25..Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. A. Gardner, "Masterpieces of Greek Sculpture." (Lecture II.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 237.

Journal of the Royal Society of Arts.

No. 3.614 VOL. LXX.

FRIDAY, FEBRUARY 24, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FUND FOR PURCHASING THE SOCIETY'S HOUSE.

THIRD LIST.*

	£	s.
Amount previously acknowledged	40,678	3
T. N. Muthiah Chetty, Esq. ..	500	0
The Goldsmiths' Company ..	250	0
Nusserwanjee Nourosjee Wadia, Esq., C.I.E.	100	0
William Henry Maw, Esq., LL.D., M.Inst.C.E.	30	0
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Onward Bates, Esq.	25	0
Edward Dent, Esq.	25	0
Hon. Raja Reshee Case Law ..	25	0
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Henry Wagner, Esq.	20	0
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C. T. Courtney Lewis, Esq. ..	5	0
Richard Alexander Murdoch, Esq.	5	0
John Ashford, Esq., M.I.Mech.E.	3	3
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K. R. Kutar, Esq.	3	3
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Charles F. Chettle, Esq... ..	2	2
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Harold Bayldon Smith, Esq., A.R.I.B.A.	2	2
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Wilfred Arthur Coote, Esq. ..	1	1
James Stewart Henderson, Esq.	1	1
Albert Alfred James, Esq., J.P.	1	1
Samuel Chapman, Esq., F.S.S...	1	0
J. J. Elmer, Esq...	1	0
	£41,810	7

The above list includes all subscriptions received up to February 17th. Further lists will be published in the *Journal* from time to time.

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will enable them to renovate and decorate the house and make it attractive and convenient for Fellows.

*The first list was published in the *Journal* of December 2nd, 1921, and the second in the *Journal* of January 13th, 1922.

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 27th, at 8 p.m. (Cantor Lecture.) ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." (Lecture II.)

WEDNESDAY, MARCH 1st, at 8 p.m. (Ordinary Meeting.) EMANUEL MOOR, "The Duplex-Coupler Pianoforte." PERCY A. SCHOLES, Music Critic to the *Observer*, in the Chair. (Demonstrations of the Instrument will be given by the Author, Miss Winifred Christie and Mr. Max Pirani.)

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 15th, 1922; SIR HENRY NEWBOLT, C.H., D.Litt., LL.D., Chairman of the Departmental Committee on the Teaching of English, in the Chair.

The following candidate was proposed for election as a Fellow of the Society :—

Armstrong, Frederick William, Manchester.

The following candidates were balloted for and duly elected Fellows of the Society: —

Forrest, L. R. W., London.

Gomat, C. S. Ganapathier, Madras, India.

Soames, Mrs. Geraldine, Rugby.

A paper on "The Necessity for Speech Training, and the Need of a National Conservatoire" was read by MR. CLOUDESLEY BRERETON, M.A., L.ès.L.

The paper and discussion will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

On Monday evening, February 20th, PROFESSOR ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., delivered the first lecture of his course on "The Mechanical Design of Scientific Instruments."

The lectures will be published in the *Journal* during the summer recess.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING

WEDNESDAY, FEBRUARY 1ST, 1922.

SIR CECIL HARCOURT SMITH, C.V.O., LL.D., Director of the Victoria and Albert Museum, in the Chair.

THE CHAIRMAN said that probably most of those present knew Mr. Wilcock already, first of all as a director for some time of an important firm of cotton printers and also as a man who had for many years been a designer in the allied art of wall-paper designing and as a man who had considerable interest in the particular trade with which the paper would deal, and particularly owing to the fact that he had had for many years a studio in his offices in Bedford Square which had served more or less as a school of design for a large number of people in the trade. He felt sure that, as Mr. Wilcock was a distributor, a designer and also a practiser generally of the two kinds of design, that for cotton and that for wall-papers, the paper would be one of extraordinary interest.

The paper read was :—

SURFACE PRINTING BY ROLLERS IN THE COTTON INDUSTRY.

A COMPARISON WITH OTHER PROCESSES OF PRINTING PATTERN FOR CRETONNE, DRESS MATERIAL AND WALLPAPER.

By ARTHUR WILCOCK,

Special Inspector of Textile Design, Board of Education.

INTRODUCTION.

GENERAL EDUCATION.

In all recent conferences and discussions on the advancement of industrial art and the improvement of public taste in the selection of what is produced, it has in the end been unanimously resolved that the public should be educated to discriminate between the meretricious and ugly and the fit and beautiful. The child must from the beginning be taught to know the reason why this thing is good and the other bad, as in morals so in the domain of *art* which has a direct bearing on morality and culture. *Beauty*, to which is allied fitness for purpose in all common objects made by man for the use of man, must come into the child's school curriculum. A child is taught to draw and paint but not to discriminate or select. We who are interested in better production realize that for such a millenium to be consummated another generation will have to appear, and that the next best thing to do is to educate the "man behind the counter." The man, coming immediately in contact with the buying public should know, at least, something about the goods he is selling and the process by which they are made.

He should also, if this is not expecting too much, be able to appreciate good design and beauty of production. When the customer approaches with an open mind he should be able to talk intelligently on his goods and transmit his enthusiasm. Enthusiasm and sincerity are the dynamic forces of business. This is quite a different thing from an offensive didacticism or an assumed intelligence. An assumed intelligence can have no enthusiasm; it is too much on its guard for an attack on its more vulnerable parts. So eventually we shall come to discredit that false and pernicious business axiom that the man who can tell the most untruths procures the best results.

These are days of specialization, and surely it must be of benefit to anyone

connected with a particular branch of trade, one who is handling every day of his life some particular production, to know and understand the processes of that production. I should consider such a one ordinarily intelligent and possessed with a desire to get on in his business.

Knowledge is power in the factory, the warehouse and the shop. It can gain and retain the confidence of a customer, it can build up a big business, it can make a great empire.

I often hear it contended that the customer does not want to know about process or design or the reason why one thing is more expensive than another, or why the expensive thing is so on account of its hand production and beauty of design and workmanship.

Limited and careful hand production at the workshop by the craftsman and unlimited production by the machine at the factory should be appreciated by the salesman, for if he mistake one for the other, which is not unlikely if he is ignorant of process, he will defraud and disappoint his customer. This is not good business.

Many things of this nature must be taken into account in intelligent and good salesmanship.

From my own personal experience as a customer in a shop and from remarks I have overheard by other customers, I deny most emphatically such a statement as that the average person does not want to know all about what he is buying. He does want information and assurance from intelligent salesmen, and he resents attention from a "dud" or a child who can tell him nothing about the goods but the *price*.

I have greater confidence in the public, and to say they do not want to know about the goods they are purchasing is a slight on my fellow citizens.

It gives one cause for great satisfaction to feel there is a great educational movement in progress among the best houses of business.

In the production of *artistic* goods it is beginning to be realized that someone who knows a little about art and design is necessary and important for the merchanting of these goods. The artist himself, provided he is not one of those with his "head in the clouds," is being sought out. Extraordinary developments are at hand in business in the search for personality in effective representation.

You all have heard the old Persian proverb—

"He that knows not and knows not that
he knows not is a fool—Shun him.
He that knows not and knows that he
knows not is simple—Teach him.
He that knows and knows that he
knows is wise—Follow him."

The whole tendency of trade now is for better education all round from top to bottom, and those members of it who are in constant contact with the public must know more, must think more and must express themselves better.

Although artistic production has advanced, it has yet much to achieve if only a higher standard of education obtains.

It is, therefore, to distributors in particular I would address myself, although if what I have to say may enlighten the designer so much the better, because for him to appreciate the possibilities and limitations of a process is an absolute necessity. The designer and artist is one always striving after new effects of ornamentation, new interpretations. It is for him to give effects that are possible by a process, but which hitherto have not been tried; to set the craftsman who follows him, whether engraver or "putter on" a difficult task; something that shall tax his ingenuity to the utmost rather than something the craftsman has done time after time before. A designer worthy of the name is one so familiar with process that he can carry it to its utmost limit of expression, always working up, never down to a dead level of the merely mechanical.

In this particular it is essential also that the producer in contact with the artist should be able to perceive artistic effects possible of achievement. Many novelties of great commercial value have been seized by a producer's keen perception of artistic effect and its possible reproduction in his process. The producer, for instance, who dismisses an artist's rough and unfinished sketch because he can only understand a mechanically finished working drawing misses many an opportunity of procuring a good thing for his business.

We will all agree then that all have much to learn and that education and more education is wanted in every department of industry and commerce. Indeed, it is now recognised as of great national importance if we are to keep our place in the world.

I shall, therefore, make no further apology for giving a paper the subject of which concerns one of our biggest national industries.

PROCESS.

The various processes used to impress cloth with a pattern in more or less permanent dye colours are many. Some of these have gone out of use in our time for various reasons. I will name them first.

1. *Hand painted.*—The *entirely hand painted*, obviously on account of its laboriousness and its co-relative cost in labour.
2. The *hand-filled*.
3. The *Batik*.
4. The *Madder style*, vat printed.
5. The *copper plate*. Replaced by the rotary plate or *copper roller*.
6. The *Perrotine*.
7. The *Stencil*.
8. The *copper roller*.
9. The *surface roller*.
10. The *hand-block*.

So that at the present moment what remain to us and have been proved under present conditions to be sound economic propositions are the three last processes which I will try to demonstrate.

The *surface roller* recently re-introduced for cotton printing, but in universal use for wall paper, for many years past.

The *copper roller* introduced as far back as 1783 by Thos. Bell.

(It is possible to combine these two in one machine.)

The *hand block*, almost as old as history and still "going strong," although at the present moment somewhat under a cloud and discredited by reason of its failure to meet the enormous recent demand. (The hand printer, through fear of unemployment, will only take a very restricted number of apprentices.)

SURFACE PRINTING.

May I venture to suggest how it came about that this surface printing of cottons was re-introduced? Some of you will remember a certain vogue of having the curtains and draperies of a room to match the wall paper. A certain eminent French manufacturer and factor of wall paper quite naturally thought the same rollers might with advantage be used for both. Simple designs rarely exceeding six colours were then in fashion. Once, however, having got the process well in hand and its many difficulties overcome, experimenting in more elaborate designs of many more colours was the sequence. This enterprising man of genius has reaped his reward in finding his goods in great demand. Genius is defined as the infinite capacity for taking pains. If one adds to this a high appreciation of design and artistic quality, you have in this Frenchman a successful art producer, compelling the attention of the whole trade by the beauty and artistic quality of his goods. He has, moreover, the satisfaction of now regarding a belated emulation on the part of some English manufacturers.

It is a process that has been in use for many years for the printing of wall papers. The more ordinary method of printing cottons and textiles by machine has been that of the copper roller, the pattern being engraved into its polished surface intaglio fashion.

Surface-print is a word used in contra distinction to this by reason of the pattern being raised above the roller.

This roller is of wood, and copper ribbon is driven in edgewise as a border to the forms which are filled in with felt. The copper ribbon stands by itself where mere lines are required in the design.

This felt has a greedy affinity for colour and will take up more than it can discharge on the cloth to be printed, some of it remaining absorbed in the felt. This is a demerit, and makes the washing and cleaning for other colour samplings a troublesome business. This dye colour heavily charged with 'paste' or gum as its vehicle also gets embedded into the interstices between the felted figuration of the design.

It is an uncleanly process compared to the copper roller which is so very easily cleansed, and is the chief reason it has been left so severely alone by the English printer for these many years.

Undoubtedly the process really serves better the purpose of the wall paper printer who uses colours which are more readily removed. Less difficulty would have to be met if no variety or change of colour was needed in a cotton pattern to be submitted to the trade, but this is contrary to usage, and many samplings showing many different colourings have to be made. A thorough washing of the roller must be effected each time or a following impression would be contaminated or dulled.

The surface of the roller presented to the cloth so nearly resembles the surface of the hand block that one would be disposed on this account to call it the "rotary block" process. Its qualities as compared with the copper roller print are in its softness of outline and general colour tone; also the tendency of the colour to what printers call "bleed" and run, giving these prints a more liquid aspect than in those textiles printed by the ordinary copper engraved roller. The finished print is very nearly the same as the hand block print and I can well appreciate its being mistaken by the trade. Many instances of this have come under my own personal notice.

HOW TO DISTINGUISH THE SURFACE PRINT FROM THE HAND BLOCK PRINT.

1. The first distinguishing feature is its narrow width; nothing yet has been produced over 30 inches. However, a 50 in. cloth may yet come from this process.
2. The register repeat spots on the margin or selvage.
3. No superposition of colours as in the Block print. Each colour must impress the plain cloth and each is edged by a darker shade of its own by reason of the profuse colour discharge on the cloth.
4. A general tendency to a lower colour tone, especially in the French product, which is usually printed on grey unbleached cloth of loose testure.
5. The "mealy" quality in half-tones of the deeper colours due to paste resist. (See Half Tones.)
6. Light blotches, or grounds, showing no joining lines as in Block work. In this one particular the machine surface process has an advantage over the hand-made print.
7. A certain streaky effect on the reverse of the print.

The rate of production as compared with hand process is a very different economic proposition—two-and-a-half to three miles a day as against twelve yards. This will make the latter hand process the only process for those firms that require rare specialities, for an exclusive trade.

The slow and necessarily costly hand block work must for ever hold its own as a special product by reason of its restricted output. It can never be made common by an enormous production such as is possible with a rotary process of printing. Speeding-up in any artistic process must inevitably lower its artistic and intrinsic value. In fact the rotary machine is a serious problem in industry by its over-production resulting in forced sales, while on the other hand, limited production gives the block a certain precious quality which alone commands respect apart from its greater permanence and artistic quality.

In like manner, if such a simile may be allowed, the precious diamond is only kept precious by restricting its supply from the mines: its value lies not only in its beauty but in its rarity. However beautiful pattern design may be, its beauty soon fades if seen in every other house and shop window.

Before proceeding further to describe this particular surface process of printing textiles we will for a moment consider the copper roller process and its real possibilities. You all know that on the surface of a bright and smooth copper roller the very finest of lines can be expressed by the graver or by an acid corrosive. Also that it is possible to get an effect equal to the finest mezzotint by the hand punch following the stipple or half etch. Such fine qualities of engraving have, however, of late years not been required. To imitate rather the breadth and largeness of the block print has been the demand of the trade. It is a matter of opinion whether such productions are a legitimate expression of the process; it may be conceded that the results obtained by this and the surface process are more decorative and less pictorial, therefore more suited to textile ornamentation. But this finer quality of the copper roller has been abused in the past and made to reproduce quite realistic effects which are in the true sense of the word undecorative. Natural flowers very beautifully rendered in all their delicacy equal to the finest mezzotint in softness of shading and gradation of tint are all very good for a framed picture but when repeated over a large surface become tiresome and are not decoration. We have yet to see these same qualities of soft gradation put to a better and more soundly artistic use. In this respect the copper roller process has not come into its own by its abuse, on the one hand reproducing heavy block effects, and on the other by reproducing light and frivolous effects; abuse by under expression,

and abuse by undecorative bad design aiming at mere realism.

It is a thoroughly sound process of impressing cloth with pattern in many ways excelling the surface process, but the prints do not possess those liquid effects which we get from both the surface and hand block print.

The finishing of the cloth in this copper process has yet to be improved; a certain stiffness is generally present which compares unfavourably with the soft draping quality of the surface print.

Here, however, may I add a word of warning to the printer of surface goods? This artistic draping quality has been due to putting the design on to cloth with little substance. It has been disappointing as a covering material for furniture on account of its flimsy texture. We cannot have it both ways, however, and seeing it is sold loosely draped and not stretched over furniture, for which purpose it is mostly used, one cannot be surprised at its popularity *as a saleable article.*

The secret of successful printing is suiting the process to the cloth on which it is going. Naturally, a rough, uneven-textured cloth is suitable for broad decorative design and an even-textured cloth for finely engraved designs. Linen with its inequality of texture has been found eminently suitable for "surface" as well as "hand block." Cotton cloth usually is too even and mechanically correct, but if in the spinning of the yarn we would arrive at the uneven qualities of the linen cloth, I am sure the surface printer would be made happy with a texture that suited his process admirably.

Demonstration.

Now let us proceed to demonstrate the "surface" process.

THE "PUTTER ON."

Our first and most important step is putting the artist's sketch on to the rollers. Each colour will have to be defined and transferred on to its separate roller—a process requiring great judgment and skill and also much experience. Allowances have to be made for *fine* fitting of the parts or sometimes a *full* fitting. In fact the "putter on" can mar the whole production of a factory if he is not something of an artist and cannot follow sympathetically the artist's original sketch.

All the rollers cut to receive their several colours can now be set up in the machine. In its rotation each roller must be very accurately registered to impress the cloth in its allotted place.

IMPRESS.

This is the contact of a colour-charged roller or block and the textile—the impressing of the already woven texture of a cloth with a dye. The pressure can be too light or too heavy. In the printing of a wall paper we have a pressure which is mere contact because the paper has no texture and the colour is nothing but pigment laid to dry on the paper's surface. In the printing of cretonne, however, some considerable pressure has to be used to feed a more or less "hungry" cloth—a term used by the hand craftsman—which has to be dried, steamed and washed and dried again before it is finished.

The contact pressure in the copper engraved roller process is tremendous. The cloth has so to speak to suck the colour out of the roller's most delicately engraved part; even those parts of the roller more deeply engraved carry but very little colour compared with the surface roller or block.

COLOUR.

All the colours used now with very few exceptions are aniline dyes. There are several groups or families of these, all of which have their different qualities.

They are:—

Acid, Basic, Direct, Mordant,
Spirit, Sulphide, Union, Vat.

Unfortunately, some of the more brilliant of these are fugitive, and while brilliant colour in pattern is required by the public it is the duty of the salesman to inform his customers of such fugitive qualities. One would be disposed to think it in the best interests of the print trade if manufacturers would desist from using any colour that has a bad reputation in this respect. It must be disappointing to the customer especially in times such as we are now going through, when economy is urgent, to discover a colour fading after a week's exposure to light; or after cleaning, however carefully, to find a flat and dead looking print with all its original brightness gone for ever.

Much of this colour non-resistance to light and cleaning depends on the failure of the colour to lay perfect hold of the cloth in printing.

I am quite sure the shopkeeper who carries heavy stocks of prints will appreciate these

remarks. I can imagine some considerable part of their time must be taken up in dealing with customer's complaints of fugitive colours. How much they would welcome for their own credit the advent of more reliable colours! We have yet to discover a gamut of colours all of which would remain fairly stedfast to light and true to their original after washing. My experience goes to show me that in this respect greater reliability is to be found in the copper-impressed pattern which is due to greater pressure allowing the colour to become thoroughly absorbed in the fibre of the cloth.

HALF TONES.

In many colour processes half tones are produced by a less deep incision in the plate or roller carrying the full tone. This is the case in the copper roller process used in cotton printing.

The half tone is called the "stipple" or, by the engraver, the "half-etch." This naturally carries less colour to discharge on the cloth than the full etch.

In the block process no such effects can be given and when a lighter tone is required another block must be supplied by the block cutter.

In surface printing, however, half tones can be given to the full tone by a very simple device. To illustrate this, I will give you, by way of diversion, a little experiment. Here is a sheet of white cartridge paper, on which I will, with clear water in my brush, draw three broad lines. Before this is dry, I will wash over the entire sheet with a green shade of colour. You will now see that the three broad lines that I put in with clear water appear in a lighter half tone. The reason is obvious. The dry sheet of paper takes the full tone and the previously damped portion of it takes only the half tone.

Apply this principle to a printing machine with its various coloured rollers set up round the "bowl." The first roller to come into contact with the cloth carries no colour at all, but merely water or "paste" and impresses this on to all parts of the design where half tones are intended. This "paste" roller must, of course, have cut on its surface parts which impress the cloth on some or all of the other colour rollers. So you will see the great service this one roller performs in producing half tones of any or all of its followers in their quick succession.

I have spoken of the old hand craftsman referring to a cloth as "hungry" when it absorbs much of his colour. This water or paste roller on the surface cotton printing machine, may be considered as having half appeased this "hunger." This method of producing half tones is not well suited to the darker colours in a pattern. The results in these cases are inclined to give a "mealy" or sooty effect--a very sure sign of differentiation from the hand block process where no mechanical half tone effects are possible.

The introduction of this "water" or half tone roller into a surface printing machine with twelve rollers, will result in giving the design all the appearance of being printed with double that number of colours. When, therefore, buyers are splitting hairs and farthings over price and manufacturing costs, they will be out in their reckoning, if in counting up the number of colours, they do not remember this wonderful but simple, device for producing half tones.

PREPARATION AND FINISHING OF CLOTH.

In describing to you the general process of preparing the cloth for printing and the after process of steaming and washing, I shall give you no more information than what you will find in the numerous technical text books on the art, but a cursory glance at the apparatus as used in some works (as you know, every works has its own tried formula) will give you sufficient idea of what the process is like. A few lantern slides will also help to illustrate what little I have to say on this very important part of the process, but which I have felt unnecessary for my purpose.

If what I have said and the views I have expressed have the effect of procuring fair play for the little hand craft of block printing I shall have achieved something. The surface roller can never produce as good a thing as the hand block, and the fact that the trade in their ignorance have sometimes passed this off as such on the public is sufficient excuse in itself, if any is needed, for my having brought you here this evening. A surface roller printed textile is a travesty of the hand craft which by its more careful and laborious process gives to the public a more lasting and beautiful production. As I

have before said, speeding up production where artistic quality is concerned is always done at a sacrifice, not only of durability in this case, but of richness and solidarity of effect. The machine by its enormous productive powers can supply the multitude and is a sound commercial proposition. If at the same time it is wisely controlled and can disseminate really beautiful patterns it is doing a good and necessary thing in the world; but when the machine-made article injures the reputation of hand-work then all right-thinking people will condemn it, and in the long run it is bad business.

CONCLUSION.

Processes of manufacture, I repeat, can be abused and perverted. I have tried to show you how much more refined the copper engraved print might be if it were true to its process and did not attempt to imitate a process which is characterised by broad massiveness, and I have also tried to show you that, through no fault of its own, the surface roller print is near akin to the hand-block process print but much inferior in permanency by reason of its more rapid and superficial process, and that the public may be made to pay dearly for what as members of an economic community they have a right, and a just right, to expect at a much more moderate price.

It is an easy matter to make a fortune by putting on the market a machine-made article which to all appearances is the same as a necessarily costly hand made article. Such kinds of trades do not rank high in a nation's credit. It is the production of the article which is what it appears to be, downright sterling in its quality. Such goods have built up British credit—goods excellent enough to attract all the world as buyers, and *satisfied* buyers who will come again for more.

DISCUSSION.

The Chairman (Sir Cecil Harcourt Smith, C.V.O., LL.D.), in opening the discussion, said that in the Victoria and Albert Museum there were examples of Indian printing dating back to the sixth century A.D., to the Coptic tombs of Egypt, through the various wonders of the Orient, the Batik printings from Java and the magnificent cotton printings from Ispahan in Persia, down to the interesting results obtained in the Jouy factories, of which the author had shown some specimens in the slides he had exhibited that evening. In the Loan Court of the Museum there was an extremely interesting series of illustrations—made, he thought, for Mr. G. P. Baker's book, to which the author had referred—showing the processes of cotton printing as used in India, those illustrations being placed side by side with the splendid collection of early cotton prints from India which were lent to the Museum by Mr. G. P. Baker. One point to which he wished to direct attention was the particular quality of cotton printing as being originally an imitative process, and in that way it was subject to disadvantages as well as to advantages. He thought it would be a great pity if cotton printing developed too largely in the direction of direct imitation of the various varieties of subjects which a copper engraving could deal with The tendency could be detected to some extent in the cotton printing of the eighteenth century, where it began to tend towards the reproduction of pictures Personally he thought there was no particular disadvantage in the register not being too exact in cotton printing: the material did not lend itself, nor demand the same sharpness and clearness of design as is necessary in wall-paper There was something in the particular nature of a textile which made softness a quality to be definitely aimed at. He thought the kind of design the author had shown in which he had introduced birds, the naturalistic form of design, which had been so popular, was in itself a step in the right direction. It was necessary, however, to avoid going too far in the direction of naturalism: if one did that one would be neglecting the primary laws of textile design Another point to which he wished to draw attention was the author's remarks about the education of the manufacturers, the designer, the distributor and the public. The authorities of the Victoria and Albert Museum were largely out for that education, but it presented enormous difficulties. If one went to the manufacturer and said, "Why do not you produce something more artistic?" the reply was, "Show me how it would pay and I will produce it;" whilst if the designer was asked, "Why do not you design something more artistic?" he replied, "Show me the manufacturer who will invest his capital in it and I will design it." Until the four elements — the manufacturer, the designer, the distributor and the public—could be brought together and something produced which would be a commercial success and worth investing capital in, he did not see how the ideal would ever be attained. It was that ideal which he hoped would some day be achieved, partly through the help of the Victoria and Albert Museum. It was with that object in view that at the present time there was an Exhibition arranged by the British Institute of Industrial Art, the primary object of which was to bring the manufacturers, the designers and the buying public together to see what

could be done The exhibits were placed side by side with the great works of the past, not with a view to having the great works of the past copied by modern productions but rather in order that the designers might be inspired by the fine traditions of the past. This country should have an English tradition in every art and in every commercial product, and that could only be obtained by the study of the great productions of the past. He agreed with the author that there were many hopeful signs at the present time. In spite of the fact that the conditions of labour, the conditions of research and the conditions of many other matters were extremely difficult, there was a distinct movement forward which was most encouraging.

MR A. F. KENDRICK (Department of Textiles, Victoria and Albert Museum) said he would like to offer his thanks to the author for a most interesting paper on a subject which intimately concerned the British public, both as users and as people who had benefited by the great industry that had grown up in this country. The author had dealt particularly with the latest process of cotton printing, the roller process, and it almost seemed as though there was nothing further to be invented in that direction. Perhaps it was a fact that the last stage in the mechanical development of impressing patterns on cotton had very nearly been reached. It was rather interesting to compare the latest process with the earlier ones. It was hardly admissible to trace back the beginnings to the East, because neither cotton nor the Oriental methods were known when the process began in this country; we had to look for the origin to our remote ancestors who used the primitive brush and pot of woad dye. That was when cotton printing began; the only thing that was not there was the cotton. In the West, the printing of books, stuffs and wall-papers, began somewhere about the fourteenth century. Those three things were very intimately associated. Just about the time that people, turning from the manuscript, learned to print books, they began to print on stuffs instead of painting them; and as far as wall-papers were concerned their patterns were very often the same as those for stuffs, which was just as well, seeing that they had to be placed near one another in the house. The next stage might be taken as the seventeenth century, when the oriental hand-painted stuffs came into this country and brought about a great revolution. They had an ancestry going back many centuries. Then one might go on from that time to the middle of the eighteenth century, when the roller came in. He noticed that the author called it the "roller," but years ago another word was used for it a good deal, i.e., the "mangle," which was perhaps a little more descriptive. By passing the stuff through the mangle and repeating the same design without a break English cotton printers were, as the author said, able to produce three miles of stuff in a day instead of twelve yards With regard to the question of education in matters of art there were so many to educate that one did not know where to begin. He thought, however, that the people really most in need were the general public The members of the general public were a little afraid of being educated, because there was an old saying about a little education being a dangerous thing. He did not believe that was true He believed that a little imperfect or a little misunderstood education was very dangerous indeed, but if people obtained only a general outline of the processes connected with the design and manufacture of the things of daily life it was a step in the right direction The people of this country had as many opportunities of seeing great works of art of the past as had the people in any other country in the world, and if they had their eyes trained by looking at those things and obtained a little insight, such as the author had been giving that evening, into the methods of production, it would enable them to distinguish between good things and the showy things which deceived so many people, and part of the present trouble would be overcome. The manufacturer, the designer and the distributor would still have to be dealt with, but he thought they would all fall into line when once the public took the reins into its own hands and learned to understand to some extent what the processes were and obtained an elementary idea of the difference between what was good and what was bad.

MR. W. H. D. KING expressed the pleasure he had felt at listening to the author's most interesting paper, and also desired to compliment him on the large audience present at the meeting and the great interest that had been manifested in block printing. Speaking as the head of a factory employing one hundred hands on block printing, he could say that block printers had always had a good friend in the author. Two points in the paper interested him very much as a block printer. One was that the artist who designed the pattern should not attempt by block printing a style of work that the process was incapable of performing satisfactorily. The author particularly emphasised that point. It must be very annoying for people to buy designs produced by an artist who had no knowledge of the craft and to find that those patterns were of no use for block work. The other point that had particularly struck him in the paper was that designs should be applicable to the cloth for which they were intended. The texture and weave of the cloth should be taken into account in the preparation of designs. Many patterns, as the author pointed out, were more suitable for linen or a rough cloth than for

a fine cloth. He did not think the distributors, who showed an increasing tendency to have their own patterns, sufficiently realised the benefit they would obtain by having particular designs on a particular make of cloth. The designers themselves should have a little more practical knowledge of the industry than they had at the present time. How they were going to obtain that knowledge he did not know. Their position was a very difficult one. They were continually asked to find something new, but there was a certain catholicity in the requirements of the public that the new did not suit, and consequently the old patterns were repeated one after the other. Some years ago he had had an opportunity of examining the old books of a print works established near Preston about the year 1798, and written against one pattern was: —"The French Belle." This is not a Canterbury-bell or a heather bell but the imaginary belle of an ingenious Frenchman from whom the no less ingenious Joseph Aumonnier copied it—but so it bring money—no matter! That proved that in those days, more than a hundred years ago, they were still copying other people's designs. He wished again to thank the author for taking up the cudgels on behalf of block printing, and trusted that those members of the audience who disposed of printed goods would remember that block printing was the best process.

Mr. R. H. Carton, speaking as a distributor, said that distributors had very great faith in block printers, but he thought it would be an advantage if they would display a little more of the ingenuity that the French printer had put into a great deal of his surface printing He did not think English block printers should be derided, because he believed they could do anything that was wanted. With regard to surface printing, a great deal of the effect seemed to be due to the fact that the surface printer printed on a natural or unbleached cloth, whereas the block printer was very fond of printing on a white cloth and thus produced a harder effect than the surface printer obtained. One reason why surface printing had such a great vogue was that it came in at a time when the spending power of the public was very limited. If the block printer would try to soften his colouring and to modify some of the very harsh effects that had been prevalent during the war and to produce simpler designs, he would have nothing to regret and would be able to hold his own against other processes.

Mr. Robert Percival Baker wished to say a few words in defence of the surface print. He would not say that the author condemned the surface print. but he felt that the author very much preferred the block print and rather criticised the permanency of the surface print. Personally he attributed that entirely to the fact that the Frenchmen who had put on to the market about four-fifths of all the surface prints that were on the market at the present time had used the wrong type of colour; they were not using the very best colours they could get. He did not profess to have analysed those colours, but from what he knew himself of the complaints that had come from the retail trade he could say they were complaints due to bad colour having been used—cheap colour. That was the cause of the lack of permanency, and not any defect in the process of surface printing. The surface machine would furnish a thin light cloth just as well as any block printer would do it. The author did not appear to agree with that, but if some of the specimens of surface printing that were exhibited at the meeting were turned over to show the underneath side it would be found that they were furnished as well as the specimens of block printing, i.e., the colour had penetrated right through the fibres practically to the same extent as in the case of the block printed article, and the prints contained as much per cent. of colour chemically fixed into them. He did not see how it could be argued that the fugitiveness of colour in the surface print was due to some defect in the method by which the print was produced, as his experience was that a surface print could be furnished as well as a block print, if the process was carried out in the right way. In his opinion surface printing was a means of bringing into the homes of the great mass of the population of this country a really good article, well designed, well turned out and at a reasonable price, whereas the block print was not within the reach of the multitude.

Mr. R. L. Jarvis, referring to the question raised by Mr. Baker as to the permanency of colours, asked if it was not a fact that the permanency of the colours was largely due to the way in which the prints were finished. If a surface print or a roller print was subject to a thorough steaming and a proper washing, would not the colours be nearly as permanent as they were in a block print?

Mr. Wilcock replied in the affirmative, [illegible]d said it was the superficial after treatm[illegible], the washing, that was accountable for the [illegible] stability of the colours. He quite agreed [illegible] Mr. Baker as to the educative power of g[illegible] designs and good prints disseminated amo[illegible] the people at a moderate price. That was [illegible] of the educative advantages of the rapid prod[illegible]cion to which he had referred. Personally, however, he could not afford to buy cheap stuff; he could not afford to buy a thing that was going to last about half or one-third the time of a more expensive article. Whilst admitting the educative value of a machine turning off miles and miles of stuff of good design, it was necessary to take into consideration the fact that it might not be permanent and its fugitive

quality might render it more fit for a duster than anything else.

On the proposition of THE CHAIRMAN, a hearty vote of thanks was accorded to the author for his interesting and instructive paper, and the meeting terminated.

CORRESPONDENCE.

PANELLING THE HALL WITH INDIAN TIMBERS.

The suggestion put forward in the discussion following Mr. Alexander Howard's paper on Indian Timbers, that one or more of these should be used in panelling the hall at the Royal Society of Arts, appears to be an excellent one from two points of view.

First, such usage would serve as a practical lesson in, and a public example of, the preferential employment of timbers grown within the British Empire, and would further serve as a demonstration of the qualities of the Indian woods used and as an illustration of the wealth of valuable, yet more or less unfamiliar, decorative woods abounding in our Empire.

Secondly, as among Indian timbers there is so wide a range of colour and pattern, it is possible to select woods from India that provide schemes of decoration producing artistic effects varying from subdued or bright monochromes to brilliant variegation.

PERCY GROOM.

Imperial College of Science and Technology,
(Royal College of Science),
South Kensington,
London, S.W.
16th February, 1922.

TRANSPORT FACILITIES IN THE BELGIAN CONGO.

In view of the extensive industrial development of the Belgian Congo during recent years, the need there for more adequate transportation facilities is becoming urgent. According to a report by the Secretary to the United States Trade Commissioner at Brussels, an expenditure of 700 million francs, allowing for the construction of new railways, having a total length of 2,380 miles, would open up vast sections of this territory suited to the growing of cotton and tropical products. The present means of transportation from these regions, the first stages by native porters, and thence by small river boats which follow the windings of the shallow streams, renders the marketing of bulky products uneconomical.

The great waterway of the colony is the Congo River, furnishing with its branches 15,000 kilometres of navigable waterways and draining over a million square kilometres of land, or more than one half the Congo. Ocean liners of 8,000 tons can dock at Matadi, about 150 kilometres from the mouth of the Congo. From Matadi merchandise is transported by rail to Leopoldville, or rather Kinshasa, a few kilometres from Leopoldville and a more important industrial centre. From Kinshasa to Stanleyville, a distance of 1,700 kilometres, the river is navigable, having a minimum depth at low water of 1.40 metres. This permits the navigation of river steamers up to 1,000 tons, but except for one 600 ton steamer the largest units in service are of 500 tons.

By comparing the costs of river and rail transportation in the Congo, it is evident that construction of new railway systems will not reduce heavily the traffic now enjoyed by the water routes. Rather, it will open up new territories hitherto inaccessible Railway rates before the war were four times those of transportation by water During the war the railways increased their rates, thereby encouraging still more the transportation by the waterways.

The Sonatra, or Société Nationale de Transports Fluviaux, maintains boats on the Congo and Kasai rivers. This organization, which has taken over all the material and installations of the Government, was constituted as a semi-private enterprise, but up to the present the Government is the sole shareholder. In addition to the Sonatra, there are several private companies which in some cases provide transportation for the products of others. Prominent among these are Compagnie du Kasai, Compagnie des Chemins de Fer du Congo Supérieur aux Grands Lacs Africains, les Huilleries du Congo Belge, and Citas. The total tonnage of the boats operated by the Sonatra is approximately 30,000, or about equal to the combined tonnage owned by the private companies.

Judicious expenditure on harbour construction at strategic points along the Congo would reduce the costs of water traffic. At present Matadi has a dock 500 metres by 50 metres. Seven kilometres below Matadi the Government possesses 500 metres of river bank at Ango-Ango, where it is proposed to construct a port connected with Matadi by rail.

The poorly constructed railway from Matadi to Leopoldville is not in a condition to bear all the traffic from that district. At the date of the armistice the capacity of the system was only 60,000 tons. However, the extensive improvements which are being urged will allow a train hauling from 200 to 300 tons to cover the distance in less than twelve hours.

THE PEANUT INDUSTRY IN EGYPT.

Peanuts in Egypt are cultivated on sandy land which is not suitable for the cultivation of other crops. The crop is sown in May, which is considered the beginning of the peanut season. During the 1915-16 season a little over 11,000 acres were sown The area was increased to over 13,000 the next season and was followed by a season of approximately 14,000 acres In 1918-19 the area sown was almost 15,000 acres and in 1919-20 approximately the same area was under cultivation

The yield varies greatly according to the locality, kind of nuts grown, and the attending soil and climatic condition The average yield per acre is about 2,000 pounds The average annual yield of nuts would, therefore, be about 30,000,000 pounds during the two latest years referred to, and although this is not a very large quantity, it is, nevertheless, very profitable to grow these nuts in Egypt, as the land used, being sandy, is not suitable for the cultivation of cotton or other valuable crops and the cost of growing the nuts is comparatively low Under present labour conditions, writes the U S Consul at Alexandria, the growing of groundnuts on otherwise useless soils yields from 50 to 100 per cent. profit on the actual cost of cultivation and harvesting, but not allowing for the cost of the land

There are three varieties of peanuts cultivated in Egypt The Sudani, a small compact nut varying in colour of shell in accordance with the soil in which it is planted, but generally pale buff or grey brown, is cultivated to a greater extent than the other varieties and enters mainly into the export trade The pods usually contain two nuts, rarely three or one The variety which brings the highest price is the Hindi, introduced from southern India. These nuts are larger than the first variety and are mostly found with three kernels The El-Huri, a nut of European origin, is a large two-celled nut, which is not grown so often in Egypt. Since peanuts have been introduced into Egypt from almost all parts of the world, the varieties have become so mixed that it is difficult to recognise them. The only variety which has clearly maintained its main characteristic is the Sudani. In October, 1920, the Sudani was valued at 32 Egyptian pounds (£E = £1 0s 6½d.) per metric ton on the Alexandria market The Indian variety was valued at 38 Egyptian pounds per metric ton.

During 1918 and 1919 the exports of peanuts from Egypt amounted to over 2,380,000 pounds, and 5,700,000 pounds, valued at £E 38,890 and £E 111,115 respectively. Palestine was the heaviest purchaser, taking in 1918, 1,667,868 pounds, valued at £E.27,778, and in 1919, 3,044,322 pounds, valued at £E.60,165. Tripoli, in 1918, took 436,674 pounds, valued at £E.6,613, and in 1919, 958,335 pounds, valued at £E.16,521. Other countries participating in the exports were Syria, Arabia, British Mediterranean possessions, Greece, Rhodes, the Sudan, and Turkey

According to the figures given above, the average yield of peanuts in Egypt is about 30,000,000 pounds per annum. Considering only the export figures for the year 1919 (almost 6,000,000 pounds), approximately 24,000,000 pounds of the Egyptian crop would be left for home consumption, to which must be added a considerable quantity imported from India, China, and the Sudan

Peanuts are used in the Near East in confectionery, but are principally consumed salted and roasted Almost the whole crop which is consumed locally is used in this manner, a very small proportion being crushed for oil.

There is no indication of an increase in the production of peanuts in Egypt, as other crops are more profitable, and land which cannot be used for the more favoured crops and which can be used for peanuts is limited, as Egypt must depend upon irrigation for the watering of crops, and the irrigation canals do not extend into the sandy regions

There are no modern peanut-oil mills in Egypt, although occasionally oil is expressed from peanuts The amount thus produced is negligible, and none enters into the export trade, although a considerable quantity of peanut oil is imported from abroad. Labour saving machinery and other similar devices are not used in the production of peanuts, and no special machines are used for expressing oil.

FUTURE OF THE INDIAN CHEMICAL INDUSTRIES

Adequate development of many Indian industries is being hindered by the need of supplies at moderate cost of the chemicals required in those industries.

Of the requisite chemicals, sulphuric acid and alkali are those most needed At present, practically every ounce of alkali used has to be imported, and it is therefore practically impossible to start an indigenous industry in which acids and alkalis are required in largo quantities. A heavy handicap is thus placed on the manufacture of glass, soap and textile fabrics—all of which industries are capable of great expansion.

It is estimated that from five to seven million pounds sterling worth of oil seed is annually wasted for want of means for utilising it in the country. The imports of soap amount to nearly a crore of rupees in value, all of which could be produced in the country from cotton seed. Many soap works have been started ; but their development has, for want of a cheaper supply of alkali, not been taken seriously in hand.

Unfortunately for herself, India does not possess extensive deposits of either sulphur or pyrites, with the result that the 4,000 or so tons

of sulphuric acid which are produced annually are manufactured from imported sulphur. India possesses, however, an almost unlimited supply of gypsum containing about 18 per cent. of sulphur, and it may be found practicable to recover this sulphur for use in the manufacture of sulphuric acid and alkalis. The gypsum may be had in some parts of India at a cost of only 8 annas per ton, and all other raw materials required for the manufacture of alkalis can be had in abundance.

If alkalis could be obtained at the price they command in Europe, it might be possible for glassworks in India to become successful propositions.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m.: -

March 1.—Emanuel Moor, "The Duplex-Coupler Pianoforte." Percy A. Scholes, Music Critic to the *Observer*, in the Chair.

March 8.—W. A. Appleton, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions." John Murray, M.P., in the chair.

March 15.—Oswald T. Falk, "Certain Aspects of the Problem of Exchange Stabilisation." Sir Robert M. Kindersley, K.B.E., in the chair.

March 22.—Principal A. P. Laurie, M.A., D.Sc., F.R.S.E., "The Permanency of Oil Colours." Sir Aston Webb, K.C.V.O., C.B., P.R.A., in the chair.

March 29.—Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.)

April 5. — Professor Ernest R. Matthews, "Sea Encroachment and its Prevention." Lord Headley, M.Inst.C.E.I., in the chair.

April 26.—John Francis Crowley, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." Sir John F. C. Snell, Chairman of the Electricity Commissioners, in the chair.

Dates to be hereafter announced:—

Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

George Fletcher, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

Philip Schidrowitz, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

Indian Section.

Friday afternoons at 4.30 o'clock.

March 24.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India."

April 28. — F. G. Royal-Dawson, M.Inst.C.E., "The Need for an All-India Gauge Policy." Sir Robert Woodburn Gillan, K.C.S.I., LL.B., in the chair.

May 26.—Professor Sir Thomas W. Arnold, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced:—

J. T. Marten, I.C.S., M.A., "The Indian Census."

Dominions and Colonies Section.

Tuesday afternoons, at 4.30 o'clock.

April 4.—Lieut.-Colonel Sir Thomas Bilbe Robinson, G.B.E., K.C.M.G., "New Zealand."

Major Sir Humphrey Leggett, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)." Date to be hereafter announced.

Dominions and Colonies and Indian Sections.

(Joint Meetings.)

Friday afternoons, at 4.30 o'clock.

May 5 Professor William Henry Eccles D.Sc. (London), F.R.S., "Imperial Wireless Communication."

Cantor Lectures.

Monday evenings, at 8 o'clock.

Alan F. C. Pollard, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." Three Lectures. February 20, 27 and March 6.

Syllabus.

LECTURE II.—FEBRUARY 27.—The Lower and Higher Pairs—Restraint against Sliding—Restraint against Rotation—Centrodes and Axodes—The Design of Profiles.

LECTURE III.—MARCH 6.—The Elastic Nature of all Materials—The Elastic Constants—The Rigidity of Instruments—Manufacture—Models—Interchangeable Manufacture.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, FEBRUARY 27 .. People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Maurice Craig, "Habit. Adaptation."

Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Graduates' Meeting) Sir Henry Fowler, "Metallurgy in Relation to Mechanical Engineering."

Electrical Engineers, Institution of (N. Eastern Centre), Armstrong College, Newcastle, 7.15 p.m.

Architectural Association, 34, Bedford Square, W.C., 7.30 p.m. Mr. Hilaire Belloc, "The Probable Effect on Architecture of the Decline in our Civilization."

TUESDAY, FEBRUARY 28 . Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. L Gaster, "Industrial Lighting Ideal Requirements (Legislative and otherwise), and Practical Solutions "

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Miss R M. Fleming, "Sex and Growth Features in Racial Analysis "

University of London, at the Imperial College, Royal School of Mines, South Kensington, S W, 5.30 p.m. Colonel N. T. Belaiew, "The Crystallisation of Metals." (Lecture II.)

University of London, at the London School of Economics, Houghton Street, Aldwych W.C., 6 p.m. Sir Josiah Stamp, "The Administrative Factor in Government."

Anglo-French Society, Scala House, Tottenham Street, W, 6.15 p.m. Mons M. Thiery, "Le Theatre d'Emile Augier."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. T. Bell, "Present Day Portraiture."

Royal Institution, Albemarle Street, W., 3 p.m. Sir Arthur Keith, "Anthropology of the British Empire." (Lecture II.)

Electrical Engineers, Institution of (N. Midlands Centre), Hotel Metropole, King Street, Leeds, 7 p.m. Exhibition of Cinematograph Films, by Dr. C. C. Garrard and Mr. F. Gill.

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 7.30 p.m. Discussion on Recording Instruments for Motor Cars.

Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. 1. Prof. J. Joly, "A New Method of Gauging the Flow of Rivers." 2. Mr. J. G. Rhynehart, "On the Life-History and Bionomics of the Flax Flea-Beetle (*Longitarsus parvulus* Payk), with descriptions of the Hitherto Unknown Larval and Pupal Stages." 3. Mr. E. J. Sheehy, "The Influence of Feeding on Milk Fat." 4. Mr. L. B. Smyth, "On a variety of Pinite Occurring at Ballycorus, Co. Dublin."

WEDNESDAY, MARCH 1 .. Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Mr. R. V. Wadsworth, "The Theobromine Content of Cacao Beans and Cocoa." 2. Messrs. A. H. Bennett and F. K. Donovan, "The Determination of Aldehydes and Ketones by means of Hydroxylamine." 3. Mr. R. E. Essery, "The Value of Fish Scales as a Means of Identification of the Fish used in Manufactured Products." 4. Messrs. N. Evers and G. D. Elsdon, "The Examination of B. P. Ointments."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. H. Cousens, "The Purpose of Economic Activities."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m Dr. C. E. M. Jones, "Surgical Tuberculosis in Children."

University of London, South Kensington, S.W., 5 p.m. Sir Frederick Bridge, "Sir W. Leighton's Great Collection of Early 17th Century Motets by Eminent English Composers" (Lecture IV.).

University of London, at the London School of Medicine for Women, Hunter Street, W.C., 5 p.m. Dr. H. H. Dale, "Some Recent Developments in Pharmacology." (Lecture II)

Electrical Engineers, Institution of (Wireless Section), Savoy Place, Victoria Embankment, W.C., 6 p.m. Messrs E. B. Moullin and L. B. Turner, "The Thermionic Triode and Rectifier "

THURSDAY, MARCH 2 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 30 p.m. Mr. W. D. Douglas, "Testing Aircraft to Destruction."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. 1. Mr. C. H. Wordingham, "The B.E.S.A., Specifications for Starters. 2. Mr. J. Anderson, "Electric Motor Starters." 3. Mr W Wilson, "Some Notes on the Design of Liquid Rheostats."

Royal Institution, Albemarle Street, W., 3 p.m Prof W. M. Lefroy, "The Menace of the Insect Pest " (Lecture I.)

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Dr. L. D. Barnett, "The Hindu Culture of India." (Lecture I.)

Auctioneers and Estate Agents Institute, 34, Russell Square, W.C., 7.45 p.m Mr. W. H Daw, "Insurance and Duties of Assessors."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Dyers and Colourists, Society of (West Riding Section) Lecture by Prof. J. W. McBain. (Leeds Junior Branch), Mr. D. T. McLellan, "Faults in Dyeing."

FRIDAY, MARCH 3 . Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Dr. C. Morley Wenyon.

Chemical Industry, Society of (Manchester Section), at the Textile Institute, St. Mary's Parsonage, Manchester, 7 p.m. 1. Capt. F. S Sinnatt, "A Contribution to the Study of the Oxidation of Coal." 2. Mrs. M. B. Craven, "On a Cause of Splitting of a Pottery Material."

Philological Society, University College, Gower Street, W.C., 5.30 p.m. Dictionary Evening.

Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. E. T. Elbourne, "Factory Administration."

Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Radio-Activity." (Lecture I.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

***For Meetings of the ROYAL SOCIETY OF ARTS, see page 259**

Journal of the Royal Society of Arts.

No. 3,615. VOL. LXX.

FRIDAY, MARCH 3, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 6th, at 8 p.m. (Cantor Lecture.) ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington, "The Mechanical Design of Scientific Instruments." (Lecture III.)

WEDNESDAY, MARCH 8th, at 8 p.m. (Ordinary Meeting.) W. A. APPLETON, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions." JOHN MURRAY, M.P., in the chair.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 22nd, 1922; SIR HERBERT JACKSON, K.B.E., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Basu, M. N., Calcutta, India.
Hayes, Sidney George, Ilford, Essex.
Orton, Charles James Swaffield, Broadstairs.
Rajhavan, S. Srinivasa, B.A., B.L., Madras, India.

The following candidates were balloted for and duly elected Fellows of the Society:—

Gidney, Lieut.-Col. Henry A. J., F.R.C.S., D.P.H, J.P., M.L.A., I.M.S. (retired), Delhi, India.
Khan, Ghulam Mohd, Lyallpur, India.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

FRIDAY, FEBRUARY 24th, 1922; VISCOUNT ELVEDEN, C.B., C.M.G., M.P., in the chair.

A paper on "Lignites and Brown Coals and their Importance to the Empire," was read by PROFESSOR WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

DOMINIONS AND COLONIES SECTION.

The Council have appointed the Right Hon. Sir Joseph Cook, G.C.M.G., High Commissioner for Australia, and the Hon. John McWhae, Agent-General for Victoria, members of the Dominions and Colonies Section Committee.

INDIAN SECTION.

The Council have appointed Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., a member of the Indian Section Committee.

CANTOR LECTURE.

On Monday evening, February 7th, PROFESSOR ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., delivered the second lecture of his course on "The Mechanical Design of Scientific Instruments."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, FEBRUARY 7TH, 1922.

THE RIGHT HON. LORD CLINTON in the chair.

THE CHAIRMAN, in introducing the author of the paper, Mr. W. Turnbull, said that every one who had had an opportunity of visiting the great forests of Western Canada would agree that they were amongst the most wonderful sights in the whole world. Most of the varieties of trees that were grown on the Pacific Coast were capable of being grown in this country and were familiar objects in our parks and woodlands, but the extraordinarily luxuriant development and the magnificence of the growth of those trees on the Pacific Coast made it difficult for one to realise that they were the same kind of trees as were seen in this country. Apart altogether from the æsthetic value of the forests, they were of enormous commercial importance, not only to the Dominion of Canada, but to the trade of the whole world, and every one must be interested in their conservation.

The paper read was: —

THE TIMBERS OF BRITISH COLUMBIA.

By William Turnbull,

Timber Commissioner for the Government of British Columbia.

I will try not to weary you with more statistics than are absolutely necessary. Therefore, I will simply state, without figures, the fact that, in spite of the increased use of steel and other substitutes for wood, the *per capita* consumption of timber is steadily increasing and is likely to do so. Our civilisation is ever finding new uses for wood and wood products, just as our remaining savagery-warfare recently found a wide variety of uses for timber.

Wood, therefore, is an increasingly important commercial and industrial commodity. To the Province of British Columbia it is vitally important. The huge stands of coniferous, or soft, woods along the freely indented coast line and in the interior of British Columbia constitute at present our greatest provincial asset. Our Government obtains a revenue of over three million dollars annually from its timber. To a population of only 700,000 people, a fair sized city population here, this amount is very important, particularly when one bears in mind that an amount equally large is required to meet our annual educational bill alone. You can readily understand, therefore, that we are intensely interested in our timber. It forms a large part of our life's blood, and the circulation of the life's blood of any portion of the Empire should cause at least a slight sympathetic throb here, in the heart of the Empire.

One of the lessons driven home by the war is the value of our Empire's timber. You remember the search for quantities of timber suitable for aeroplane construction and how it was finally discovered that British Columbia produced the type wanted in its light, but tough and strong, Sitka Spruce.

One of the results of this search for aeroplane stock and other timbers for war purposes was a general stock-taking of the timber resources of the Empire, culminating in the Imperial Forestry Conference in this city in 1920, from which has sprung the Empire Forestry Association.

According to the Whitford-Craig report, the only record we have to guide us, British Columbia has a stand of commercial timber of 366 billion feet, roughly, 200 million Petrograd standards, or one-third of Canada's total stand. Of this total, 350 billion feet is of saw-log size, which, in British Columbia, is of 10in. top.

Roughly, two-thirds of this stand is on, or adjacent to, the coast, and the balance in the interior.

The total area of forest land in British Columbia is estimated at 149,000 square miles, of which 115,000 square miles are still in possession of the Crown, the balance being nearly equally divided between lands Crown granted and lands held under timber licence, lease or sales.

About one quarter of the estimated stand of timber is still in possession of the Crown. Crown timber is now disposed of only by tender, an upset price being set by the Forest Branch.

Our chief commercial timbers are Douglas Fir, Sitka Spruce, Western Hemlock, Red Cedar, Western Yellow Pine and Western Larch. Of these, you are chiefly interested in the first two, though our Hemlock ought to be better known in this country.

Douglas Fir (*Pseudotsuga taxifolia*).

The most important of our woods is undoubtedly Douglas Fir, known throughout the world under various names, the chief here being Oregon Pine and British Columbia Pine.

As a matter of fact, Douglas Fir is, strictly speaking, neither a fir nor a pine. The name Oregon Pine, which, by the way, the Oregon people are seeking to revive in place of Douglas Fir, was first given to this wood by accident. Dr. McCullough, a Scotchman and the first Hudson Bay factor at Fort Vancouver in the territory of Oregon, named it Oregon Pine in this way: A schooner arrived from the Hawaian Islands with sugar and a request to the company for a return cargo of timber. Natives were set to cut down the huge trees; saw them up, and load the vessel. McCullough's chief clerk asked how he should describe the timber in the manifest. The doctor, who was something of a botanist, said "It's neither Pine nor Fir, but it's nearer a Pine. Call it Pine." "What sort of Pine, sir?" asked the clerk. The doctor thought for a moment, and then said:— "This is Oregon, call it Oregon Pine." The name was picked up by sailing-ship captains who had to ship masts and renew spars on the Pacific Coast,

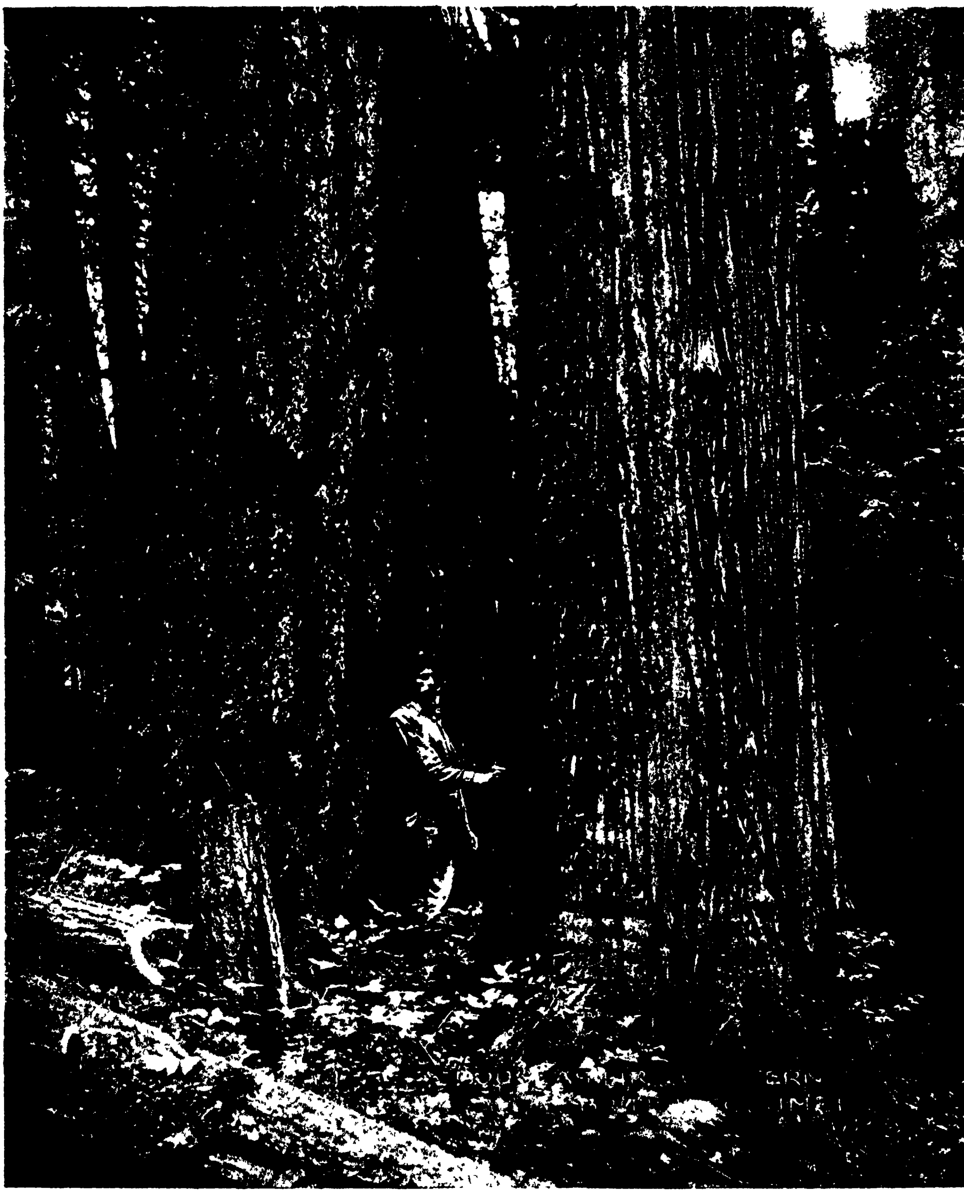

Fig. 1.—Douglas Fir and Red Cedar.

and the sailors carried it to every port in the world. The sailor was a great advertising agent, and his work still shows big results after all these years.

Early in the 19th century, David Douglas, a Scotch botanist, was sent out to the Pacific Coast by the Horticultural Society of England. Douglas found this magnificent tree; decided it was nearer a fir than a pine, and called it Douglas Fir, which is now its recognised trade name all along the coast. In this country, you seem to prefer the term pine, largely, I suppose, because of your high regard for the Yellow or Pitch Pine of the Southern States. There may not be much in a name, but we sometimes find a good deal of trouble in two names, and it is not surprising to find people who believe that Oregon Pine and Douglas Fir are two distinct species. Men in the timber trade have told me that they did not handle Douglas Fir, but that they liked

Oregon Pine. They are one and the same tree.

British Columbia has 76 billion feet of Douglas Fir, which comprises 21.7 per cent. of our total commercial timber stand. It is the most important tree on the North American continent and grows to enormous size, as you may judge from the single-stick flagstaff now in Kew Gardens. We have Douglas Fir trees 300 feet high and 15 feet through at the butt. Commercially speaking, of course, average sized second growth timber is more valuable. We naturally use a great many adjectives about it, but one cannot over-emphasise the good qualities of one's best friend, and Douglas Fir is British Columbia's best friend.

It varies in colour from a straw-yellow to a reddish-brown; is moderately hard, yet easy to work, straight-grained, tough, resilient and durable. It takes stains well, holds nails firmly and does not worry about water.

The great value of Douglas Fir is in the wide variety of uses to which its lumber may be put. Its great strength, coupled with comparatively light weight, makes it ideal for heavy structural work, such as supports in large buildings, bridge and ship timbers, framing for houses, planking for scows, dredges, etc. It is also equally suited for all dimension material, such as joists, scantling, etc., in any kind of building to be exposed to any kind of weather.

We have in British Columbia houses built of Douglas Fir sixty years ago still occupied and in good condition—and the climate of British Columbia is not particularly dry in fall and winter. We find Douglas Fir remarkably durable.

Your Great Western Railway Company has furnished us with evidence of the durability of this wood when creosoted and used for sleepers. Out of 616 sleepers tested only 23 were removed on account of decay in 17½ years.

You may be interested to learn that city engineers in Canada and the United States are to-day giving exactly the same working stresses for Douglas Fir and Pitch Pine, after years of experience of both woods. Hundreds of tests carried out by the U.S. Forest Products Laboratories show Douglas Fir to be equal in strength to Southern Pine, in fact, in elastic limit to be 10 per cent. stronger. Douglas Fir is the strongest wood in the world, for its weight. Railroad companies in Eastern Canada use much of it in car construction for sills, etc.

Besides being invaluable as a structural timber, Douglas Fir, sawn edge-grain makes a very fine flooring, wearing evenly and taking a splendid polish.

In Canada we use much more wood-panelling in our houses than you do here, and for this purpose and other interior finish, Douglas Fir is the most popular wood. The figuring is distinctive, and when the grain is fine and "curly" a remarkably beautiful effect is obtained. It finishes and polishes splendidly. The best effects are of course, obtained from veneer cut panelling as panels may be matched very closely.

SITKA SPRUCE (*Picea sitchensis*).

We now come to Sitka Spruce, the best known of our spruces. It is found throughout the Douglas Fir region, but is at its best on the north of Vancouver Island and north of the fir belt on the Queen Charlotte Islands, particularly on Graham and Moresby Islands of that group. From Graham and Moresby Islands, British Columbia shipped, during the war, enough Sitka Spruce to construct 20,000 aeroplanes. Your timber research men here found that Sitka Spruce met their requirements of lightness with strength, toughness, even grain and freedom from splitting. When active fighting ceased, the Imperial Munitions Board immediately dropped operations and lost all interest in Spruce. Many millions of feet of the cream of our Spruce lay in the woods and the water, the latter subject to teredo attack. This large stock of splendid material was ultimately sold at salvage prices to be sawn into lumber and chewed up into pulp to make paper. Possibly this was the best plan of disposal at the moment, but it seems a pity that such quantities of valuable aeroplane stock should be devoted to giving racing results to the public. I venture to think that the Germans or the Japanese would have valued it more highly.

I say it seems a pity that its world value should so soon have been lost sight of, just because active fighting suddenly ceased. The war did *not* end on November 11th, 1918, any more than it began on August 4th, 1914. The struggle for world supremacy began soon after 1871 and is still proceeding. True, military efforts ceased in 1918, but the struggle continues

FIG. 2.—Sitka Spruce Stand on Queen Charlotte Islands, B C.

in marks, francs, pounds sterling, dollars, and yen, in commerce and industry. Shall we require that spruce again? One wonders.

To-day, much Sitka Spruce is going into pulp, but it is also being made into boxes of all sizes. Its freedom from taste or smell makes it invaluable for containing foodstuffs. It is also being used for framing, sheathing, and sub-flooring, while it is more than useful as core stock for veneered articles. It is also one of the most resonant of woods because the fibres are long and regularly arranged, and is now being used in making piano sounding boards, and cabinet gramophone horns; I find in Britain that it is in high favour with violin makers.

Like most British Columbia woods it is obtainable in large sizes, much of it clear.

WESTERN HEMLOCK. (*Tsuga heterophylla*).

Western Hemlock is not so well known over here as it is in Canada. It constitutes 18.3 per cent. of our commercial timber and, like the others, grows to large size. Even in Canada, its good qualities and value are not so well known as they will be. To-day, much of our Hemlock goes into pulp, for which it is admirably suited, but, for ordinary building purposes it is just as useful as Douglas Fir. It has 88 per cent. of the strength of its bigger brother and is not so suitable for the heaviest type of construction, but it makes excellent siding, flooring, ceiling, scantling, inside joists, etc. For sash and door fixtures, turned stock, panelling, etc., it has exceptional merit.

Western Hemlock is usually light in colour and contains no pitch or resin. It dresses to a smooth satin-like surface capable of taking a very high polish and is not easily scratched. Sawn slash grain, it shows a very handsome figuring.

I notice that you are fond of enamelled woodwork in this country. Western Hemlock takes enamel finish to perfection.

Edge-grain Hemlock flooring has proved invaluable. It hardens with age and we have an instance on the Pacific Coast where it has been down for 50 years and is now so hard that it is difficult to drive a tack in.

Canadian railway companies are using it for car flooring, siding, etc., and find it highly satisfactory.

The Japanese, who use large quantities of our fir and cedar, have become aware of the good qualities of Hemlock and are now asking for it.

Toronto Harbour Commissioners have put seven million feet of our Hemlock into Harbour work in the past few years, and the Dominion Government are using it in construction of part of their big dry dock at Esquimalt, near Victoria, British Columbia.

It is also very popular as a box and packing case material. One firm on the Coast is shipping 50,000 oil cases of Hemlock to Singapore every month.

Incidentally the Hemlock bark is very rich in tannic acid, but this industry has not been developed yet on the Coast.

RED CEDAR (*Thuja plicata*).

Western Red Cedar, another of our giants, is not much used in this country, but is a very important wood. In some ways it is more important than any of the others. It is the overcoat for our houses, in the form of roof and siding shingles, and, while I may be prejudiced, I believe they are much more artistic as a house covering than slates or tiles, while they keep out the heat in summer and the cold in winter. Rain or snow on a shingle roof is like water on a duck's back. Red cedar may, with the Southern Cypress, be described as the "wood eternal." Trees which fell in the damp woods of British Columbia centuries ago are found to-day perfectly sound and fit for shingles and lumber. It was from the Red Cedar that the Indian hollowed out his war canoes, split planks for his lodges, and carved his historic totem poles, and his judgment was sound as usual. (The Totem pole must have been the origin of the term "family tree.")

The wood is exceptionally light, soft and of close, straight grain, making it easy to handle and work. It is remarkably free from warping, shrinking or swelling. The narrow sapwood is white, and the heartwood runs from a light yellow to brownish-red. It is invaluable for all outdoor work as all weathers are alike to Red Cedar. It is our great fence and pole material, requiring no treatment or preservative. The butt will stay sound for years and years under any conditions, and for siding, lattices, pergolas, arbors, summer houses, green houses, etc., it is unequalled.

It is also very effective in interior work though its softness renders it liable to denting in low panelling. For beam ceiling work it is exceedingly handsome. Finished naturally, it acquires with age a silvery silky sheen which is very beautiful.

One of the great qualities of the British people is loyalty to old friends. An inherent part of this loyalty is a slowness in making new friends, even in woods. When a new timber acquaintance is adopted they do not like to admit the newness of the friendship and very often dress up the newcomer to resemble an old friend. For instance, I have seen here some magnificent panelling of British Columbia Red Cedar, but British Columbia timber men would scarcely recognise it. It is beautifully dressed, but disguised so as to resemble mahogany. It has not the mahogany quality; and it is ruined as cedar. Our Red Cedar, when finished naturally, mellows with age and takes on a beautiful silvery sheen, but a mahogany overcoat hides all this for ever.

We have another cedar—the Yellow Cedar or Cypress—which is not at the moment of commercial interest. It is found only in scattered stands, above the 2,000 feet level on the lower coast, but at tidewater farther north. It is similar in outward appearance to the Red Cedar; the wood is sulphur-yellow in colour and is the heaviest and most durable coniferous wood in the Province. It is easily worked and takes a beautiful satin-finish, which renders it especially useful for finish and cabinet work.

It is practically unaffected by atmospheric changes and is very valuable for boat-building, greenhouses, battery separators,

etc., and is said to be immune against the teredo. The latter statement I cannot vouch for. There is a considerable quantity on the Queen Charlotte Islands, but it is being logged only incidentally and is very hard to get. Clear Yellow Cedar makes a very high price.

COTTONWOOD (*Populus trichocarpa*).

Another interesting wood is our Black Cottonwood. It is found in river bottoms on Vancouver Island, along the Fraser River Valley to Prince George and in the Skeena and Naas River districts north and east of Prince Rupert, the terminal of the Grand Trunk Pacific Railway. It is the only deciduous tree in British Columbia which is of commercial value.

The wood is grayish-white, soft, odourless, tasteless, straight and even grained, very light, long fibred and easily nailed, glued and veneered. It is an ideal box material and its great strength, compared with its light weight, renders it especially valuable in making laminated wood products.

It is now in demand for carriage and automobile bodies, and in the near future will be much more highly valued than at present.

These, with the exception of the small firs, which we do not consider as individually of great importance, comprise our chief commercial woods adjacent to tidewater.

INTERIOR WOODS.

Our interior woods, though of great value to British Columbia, are too far from the ocean to be brought over here successfully.

FIG. 3.—Logging Operations in British Columbia.

The most important of these are the Western Soft Pine, and Western Larch. They are the important woods of the southern interior of the Province, but I do not propose to deal with them in detail.

LOGGING.

The improvement in logging methods is a clear index to the increased timber business of British Columbia.

In the "seventies," when the Government's annual revenue was about $600 - roughly £120—teams of heavy oxen provided the motive power. The spark was supplied by the teamster who, in addition to a business-like hickory goad as his badge of office, had a command of sulphurous language which seemed to burn its way into the brain of even an ox. Increased demand required greater speed and horses and mules superseded the oxen. Mule-driving also required high-power language.

To-day, steam has ousted the horse and mule, and is now being helped out by the motor tractor.

The logging superintendent of to-day carefully maps out his timber area in profile; selects his "spar-trees" at strategic points, and lays out his main railroad line and branches. Besides knowing his timber, he knows every "kink," rise and fall in his area.

The donkey engine and high "spar-tree," with rigging attached, alongside the loading track with its train of skeleton flat cars, are the central features of present-day logging operations in British Columbia. From a radius of 1,200 to 1,500 feet huge logs are hauled by overhead cable from off the mountain slopes to the cars just as easily as a trout is brought to landing net on a line.

Logging is no longer confined to timber close to tide-water, and logging railways run back into the woods from ten to thirty miles. Train-loads of logs are brought down; dumped into the sea, formed into booms and towed to the mills. Booms of logs are towed long distances and, in the land-locked coast waters, the percentage of loss is small.

The Davis patent whale-back rafting method is also used successfully, but the old sea-level boom is still the most popular.

From a timber conservation standpoint, our logging methods are extravagant and visitors from Europe are apt to hold up their hands in horror at the amount of waste left in the woods. We are a young country, and the young are not apt to think much of the distant future. Some one has said "Happy is the nation which has no history." We are somewhat in that happy position, but it has disadvantages, one of which is a light regard for posterity.

However, there is usually a reason for everything and, paradoxical as it may seem, the reason for our extravagance in the woods is economy. In British Columbia, labour, food, logging machinery and equipment and towing costs are high. It costs as much to get the skimmed milk as the cream, as it were. We have been in the habit of looking on our forest resources as inexhaustible, and have acted accordingly.

We have been "mining" timber instead of cropping it, but the day is at hand when we must think of future crops, and our Forest Service is taking steps towards that end. Just recently the Hon. T. D. Pattullo, Minister in charge of that Department, spent some time in Sweden looking into Swedish methods.

FOREST SERVICE.

Our Forest Service was inaugurated in 1912; the war broke out in 1914 and our staff became a mere skeleton, but we have now reorganised on a stronger basis than before.

On the British Columbia coast we have prolific forest reproduction and the young growth makes rapid progress, so that re-forestation in many parts can be safely left to nature. Eighty per cent. of our energy and expenditure is devoted to protection from fire. Huge areas have been burned over in past years, and repeated burning ruins the seedbed; it is most important that we should keep down forest fires. To this end we employ a large staff of fire rangers every season. We have 80 automobiles in this service, armed with the latest type of fire-fighting pump, six seaplanes for reconnaissance work on the coast, and a fleet of fast launches. These launches are fitted with wireless telephones, in constant touch with wireless telephone stations along the coast right to headquarters in Vancouver. Headquarters, therefore, knows just what the fire situation is at any time and is immediately able to direct a force of men to any danger point.

Fig. 4 — Hotel built of Douglas Fir, with roof of Red Cedar Shingles.

Output and Markets.

British Columbia has over 400 saw mills, ranging in capacity from 5,000 to 200,000 board feet per shift, and including the largest sawmill in the world. Over 50 per cent. of the mills are on the coast and they manufacture 80 per cent. of the total cut.

The huge logs are handled by powerful machinery, not being touched by hand until sawn into lumber.

British Columbia's annual timber cut is about two billion feet, or about one million Petrograd standards. Our annual natural increment is estimated at five times this quantity, hence the eagerness to extend our markets. We have a large but variable market on the Canadian prairies; a large and steadily growing outlet in Eastern Canada and the Eastern States, but we look to overseas markets for much of our future growth, and we think we are not looking in vain.

Our overseas trade has grown from 43 million feet in 1916 to 170 million in 1921. Of this amount Japan and China took 93 million feet, Australia and New Zealand 27 million, the United States 14 million and the United Kingdom nine million, the remainder going to Egypt, South Africa, India and South America. From these figures you will gather that our logical market is on the Pacific, though there is still much business going from here to the United States which might just as easily be placed in British Columbia. Were British Columbia located where Sweden is, she would undoubtedly supply the United Kingdom with all her soft woods.

However, we are hopeful of shipping increasing quantities of timber here, as the Panama Canal has brought us nearly 6,000 miles nearer to this market than we used to be. We are able to market clear timber in much larger sizes than can be obtained in Europe, but the largest demand here is for lower grades, which, under normal conditions, will not stand the freight from the Pacific Coast though rates are now getting to a figure which opens up greater possibilities.

One handicap our manufacturers labour under in this market is that, in addition to the short haul from across the North Sea, they have also to contend with Swedish specifications. As you can judge from our forest scenes, British Columbia logs cannot be cut to length to order. We are cutting down primeval forests of timber of immense size, not harvesting a crop of uniform size and grades.

In Sweden they can afford to take time to carry out every operation scientifically

to the most minute detail. In British Columbia, with our high costs and long haul, we must make speed of production our first aim.

Our large business has been a home rail business, and our methods have been based on the requirements of our largest market.

Our proportion of British business has not been large enough to stimulate enthusiasm and keen interest amongst our manufacturers. The distant British market has not been capable of absorbing more than a third of our log; therefore, largely increased trade here meant either over-loaded yards or flourishing business in common grades at home. However, we are shipping more timber here than we did, and what would mean a little more to you, means a great deal more to British Columbia. We are closer together in every way than ever before, and we confidently look for an increased interest on both sides.

PULP AND PAPER.

In closing, I should like to say a little regarding our pulp and paper industry, which is still in its infancy, but is a very healthy, sturdy youngster.

We have four pulp and two paper plants, and production has grown from practically nothing in 1912 to an output of 136,832 tons of newsprint; 9,792 tons of wrapping; 5,300 tons of sulphite and 9,000 tons of sulphate pulp in 1920.

With abundant water-power, supply of 180 billion feet of timber saw-log size of species suitable for pulp, large stands of young growth working day and night from spring to fall to attain pulping size, and splendid harbour facilities, this industry is capable of enormous development.

Five new pulp companies are preparing to start operating and more will follow. Pulp stands in Eastern Canada and the Eastern States are being rapidly depleted and the attention of the manufacturer and the capitalist is turning to the west.

We are naturally optimistic in British Columbia, and we have ample grounds for our optimism.

DISCUSSION.

THE CHAIRMAN (LORD CLINTON), in opening the discussion, said he was sure all those present had listened with very great interest to the paper, which, with the excellent film that had been shown, had given a very good idea of the immense work connected with the forests of British Columbia. At the beginning of the paper there was a reference to the constantly increasing consumption of timber per head of the population, and that was going on in spite of the many substitutes for timber for construction purposes that had been found. He had the honour to be a member of the Forestry Commission, which had to consider very carefully from what sources the future demand for timber in this country was going to be satisfied. The great forests of British Columbia were among the last great stands of coniferous timber. The natural timber available in the forests of the world was at one time supposed to be practically unlimited, but it was perfectly clear now that those forests, partly on account of their use for commercial purposes and partly on account of the great enemy, fire, were certainly exhaustible. It was impossible for any one to tell what their actual life would be, but it was necessary to look forward to a time when the imports of timber into this country must decrease. It could not be expected that the efforts of man would ever rival the ancient timbers that had been used from those forests in the past, and unfortunately at the present time not only had the axe been laid to the root of the tree to demolish those forests, but the "axe" had been laid to the root of the finances by means of which it was hoped to grow forests in this country. Efforts would, no doubt, be made to carry on the work, but, in view of the fact that the ordinary supplies of timber to this country from the New World and, most important of all perhaps, from Russia were disappearing, the outlook was not a happy one. He thought it would be of interest if the author could state what would be the probable increase of imports of timber into this country from Canada. He understood from the figures given by Mr. Turnbull that this country consumed about 9,000,000 board feet of timber per year from British Columbia, but it was quite certain that very much more than that would be required in the future. Our chief competitors for that timber were on the Pacific Coast, and he supposed the natural market for it would be the Southern States of America, which were coming to the end of their own timber supplies. The opening of the Panama Canal would, of course, be a great factor in bringing the timber to this country. There was one other point upon which he would like to touch, because it was of importance to those who were dealing with timbers in this country in relation to the vast area of Empire forests, which amounted to about 1,200,000,000 square miles—namely, the nomenclature of timbers. At the Forestry Conference held in this country two years ago our foresters talked in quite a different language in trees from the overseas foresters abroad, especially those from Canada. The latter used largely the trade names, which, as the author had said,

were arrived at in a haphazard way, while in this country the botanical names were generally used. The tree that was known in British Columbia as the Sitka spruce came into this country as spruce, but the name "spruce" was generally used here for the spruce of Norway and other parts of Europe, which was quite a different timber. The Sitka spruce was certainly going to be of great value in this country, and the Forestry Commission now had many millions of young plants in their plantations Again, the author spoke of hemlock, which was a very familiar tree in this country, grown under the name of *Tsuga Albertiana.* It was valuable not only for its beauty in our parks, but for its sylvicultural characteristics, which made it worthy of more cultivation than it had had up to the present time.

PROFESSOR PERCY GROOM, D Sc, said the author was to be congratulated on the interest and importance of the paper. Personally, he would venture to emphasise the importance of British Columbian timbers by reference to only two timbers, the Douglas fir and the Sitka spruce If one thought of the supplies of large dimensioned constructional timber in the world and left out of account the problematical large Scotch pine of the Northern Russian dominions, there remained only two coniferous timbers that could yield us big constructional logs, *i.e*, the Douglas fir and the pitch pine. The author had stated that ten years hence, according to an American authority, there would be no more pitch pine exported from America, so that the supplies of that big timber were being exhausted When that exhaustion was complete there would remain in the world only one stock of the large dimensioned coniferous timber, *i.e.*, the Douglas fir When that, too, was exhausted there would never be any more in the world, so far as could be judged by modern forest policy, for that policy was to obtain the maximum return at a short rotation of about 70 years. Therefore British Columbia had got a very remarkable and indeed a unique treasure, and one wondered very much from an Imperial point of view what she was going to do with it With regard to the second British Columbian timber with which he proposed to deal, the Sitka spruce, which the author pointed out was used during the war as an aeroplane material under the name of "silver spruce," that timber was of vast importance, because it had that unique combination of elastic and strength qualities and what was fundamentally important, excessively slow growth, narrow rings, that made it at any rate an unrivalled aeroplane timber at the present time. When that stock was gone he did not know where any other existed that could take its place The question was, Would it be needed ? Some people said that in the future aeroplanes would be made entirely of metal. Assuming for the moment that an all-metal aeroplane was superior, it must be remembered that wood was a semi-manufactured material and that by the aid of a few simple machines and very unskilled labour—the labour of girls—the complete parts of an aeroplane could be manufactured. Therefore, he could not help thinking that timber would be a very valuable accessory material even if metal aeroplanes were used in the future. One other use of the Sitka spruce deserved consideration, because it might provide this country with a means of capturing a key industry. The author had mentioned in his paper the use of Sitka spruce for piano sounding boards and for violins. It must be remembered that the most careful workmanship and the best design would not make a good piano if there was a bad sounding board. Before the war the European sounding boards were made of the ordinary European so-called Norway spruce, and the best of that timber came from a definite height up the mountains, being easily recognisable by certain characteristic markings that could be identified with the naked eye. That very best material, which was formerly grown in Switzerland, France and Germany, had receded from those countries and was now left only in the vicinity of Roumania, so that the European supply of piano sounding board of the best quality was doomed to extinction. It was, like the Sitka spruce, a very slow-growing tree. In the past, he believed, Germany had the complete control of the best quality, the high merit of the German pianos being due to that control and to the fact that the manufacturers did not mind what they spent so long as they got a good sounding board, whereas the manufacturers in this country were prone to prefer buying cheap sounding boards, regardless of the tone resulting. During the war many samples of British Columbian spruce passed through his hands at the Air Ministry, and he was delighted to find that in British Columbia there was a considerable stock of the peculiar piano sounding board spruce, with its characteristic markings. Its elastic properties conformed with its structure. He hoped that the Government of British Columbia would bear in mind the enormous wealth that might be represented by that particular timber.

LIEUT.-COL. SIR DAVID PRAIN, C.M.G., C.I.E., F.R.S., said he had listened to the paper with much profit, but not with unmixed pleasure. With regard to what the author had said about the various individual trees, he felt very interested and had learned much. But when the question of logging was dealt with that was a very different matter, and Mr. Turnbull had himself frankly admitted the delinquencies of his country and had said that from a timber conservation standpoint the logging methods adopted in British Columbia were extravagant.

He felt he must criticise those who were responsible for the use of the word "illimitable," in connection with the forests of British Columbia, on the Government film that had been shown. That adjective was not applicable to the forests of any country when men exploited them. As a matter of fact, it was our enemies rather than our friends that we liked to hear boasting about the output of their timber and the rate at which they were exporting it to countries that were not friendly countries, or, if they were friendly, were trade rivals of our own. The beautiful pictures that had been put on the screen showed very clearly the extraordinary skill with which the logs of which the British Columbian hillsides were being denuded were handled and taken away, but—he did not know whether intentionally or through an oversight—no picture was shown that gave the faintest idea of the effect upon the hillsides so treated. It would have been interesting to see a picture of some of those hillsides after the timber had been taken away from them. With regard to the question of pulp, he was very sorry to hear the author boasting about the increase in the output of pulp, of which British Columbia seemed to be so proud. He would like to ask the author what was done with that pulp and also what it was made of. He thought the time was coming when the various communities interested in the matter would have to forbid pulp being made from the timber of any tree that was of the slightest use for any other purpose. The bulk of the pulp used was employed for an ephemeral purpose, for making paper for tradesmen's circulars and for daily newspapers and such things. The question of the disposal of pulp was a most serious one, and he thought that Governments which had the interests of the communities they governed at heart would have to take steps to say what might and what might not be used in the way of timber to produce pulp that was to be employed for ephemeral purposes.

MR. J. S. CORBETT (Secretary of the Empire Forestry Association) said he had had the privilege of listening to many papers on the timbers of the Empire read before the Royal Society of Arts, and he thought the present paper was one of the most valuable. After hearing them he had come to the conclusion that there were within the Empire sufficient timbers to meet the needs of Great Britain and that those timbers were equal, if not superior, to those produced by any other countries in the world. He thought the papers should be followed up, and that it was important to get into touch with all those who were responsible for the use of timber in any shape or form, and to bring home to them the information contained in those valuable papers. It was known from the statistics published that the value of timber and timber products imported into this country in 1920 was £120,000,000 and of that amount probably 80 per cent. came from without the Empire, and yet there was timber within the Empire which ought to be used, and probably would be used if only its properties were appreciated and pressure brought to bear upon the Government and upon public bodies concerned with the use of timber. The streets of London were paved with timbers, the majority of which came from Scandinavia, but he was glad to say that within the last twelve months Canadian spruce had been specified for the first time. In England, also, there was timber which was equally suitable for paving-block purposes as was the imported Scandinavian He thought what was required was a really sound business organisation to get into direct touch with those who were responsible for the drawing up of contracts where timber was concerned. The reader of the paper had referred to the Imperial Forestry Conference which was held in 1920, and also to the Empire Forestry Association as being one result of that conference. Personally, he happened to be the first Secretary of that Association, and he felt that, as Mr. Turnbull had said, there were enormous possibilities before the Association, provided it could obtain the confidence of all those who were interested in the production and exploitation of Empire timbers and provided also that it could receive sufficient funds to enable it to carry on the work it had undertaken The Chairman had referred in his speech to the possibility of the grant to the Forestry Commission being reduced It should be realised that probably three-quarters of that grant was spent on British labour, and the grant was being utilised to provide work for some of the unemployed at the present time, and it seemed incredible that there should be any suggestion that that small grant, which he believed was to be £200,000 for the next year, should be criticised in any way, considering the enormous importance of the subject. The Secretary of the Australian Forest League told him recently that the League exercised a very considerable influence on the election of the Australian Legislature. Could one imagine any aspirant for Parliamentary honours in this country being heckled on the subject of forestry by one of his constituents at a public meeting? Australia exported timber to the value of about £2,000,000 per annum, and yet Great Britain, which imported timber to the value of over £100,000,000 per annum, had no forest conscience and took little interest in forestry problems. He hoped the Empire Forestry Association would be able to create a real forest conscience amongst the general public and make them realise the importance of timber problems. The author had not referred in his paper to the resolution which was passed at the Imperial Forestry Conference with reference to the establishment of the Imperial Forestry Bureau.

If the work undertaken by the Empire Forestry Association was to be a success, he thought it was absolutely necessary that a permanent exhibition should be established of timbers of the Empire, which were a commercial proposition. All the mahoganies should be grouped together, the teaks, the soft woods and so forth, and information should be available as to their tests, the probable price and the quantity that was available. If there was such an exhibition, he believed it would be possible to secure the interest and confidence of architects and others responsible for the drawing up of the various contracts. Another thing which he thought was necessary was information as to the consumption of timber by the large railway companies, shipbuilders, harbour boards and municipalities. That information should be drawn up under certain headings, such as the quantity, the species, the price paid and the source of origin, and it would then be possible to ascertain whether timbers from within the Empire could be substituted for those which were now imported into this country from without the Empire. He had recently had an opportunity of inspecting some harbour works in the north of England, and he found there greenheart from Cuba being used, whereas British Guiana was asking for an outlet for her greenheart. The greenheart from the Colonies could be supplied at less cost than the contractor was paying for Cuban. He found also that bridges were being paved with the very finest pitch pine, and he was sure there must be within the Empire timbers which were equally suitable for that purpose. The exhibition having been established and the information he had suggested having been secured, the next step to be taken was to form a central clearing house for information on all matters relating to forestry problems, and information such as the author had given on the present occasion and such as had been given before the Royal Society of Arts on previous occasions must be spread broadcast and an effort made to interest the public in the importance of the problem.

Major F. M. Oliphant (Department of Scientific and Industrial Research) said he had lived in British Columbia and worked in timber mills there, and there was one remark he would like to make with reference to the western hemlock mentioned by the author, and also with reference to the Chairman's remarks on the confusion that existed in the timber world owing to the difference in nomenclature in different countries. In Western Canada the western hemlock was used, and in Eastern Canada there was a timber called the eastern hemlock. The two were different species, the western hemlock being the *Tsuga heterophylla* and the eastern hemlock being the *Tsuga canadensis*. The western hemlock was a very fine timber; it had a straight grain and was cleaner, harder, more durable than the eastern hemlock, and without its brittleness. Its properties in general were very much more suitable for work where good timber was required and certainly for interior work, than those of the eastern hemlock. The eastern hemlock was very rough and knotty, it warped and shrank, it was coarse and crooked in grain and very brittle. The only good property he had ever heard attributed to it being that it lasted very well under water. As far as he could recollect, it used to be employed in British Columbia for the forms used in reinforced concrete buildings and for rough general constructional purposes. Unfortunately, people in this country and in Canada sometimes complained that hemlock timber was useless, when their knowledge of that timber was confined to the eastern hemlock.

Mr. Byron Brenan, C.M.G., in proposing that a hearty vote of thanks be accorded to the author for his valuable paper, said he was confident that every one present had listened to the paper with great interest. He did not quite agree with Sir David Prain in deploring the use of timber for making pulp. After all, the paper on which the proofs of the author's paper were printed might be made of British Columbian pulp, and he was sure nobody would say that that paper had been used for a subject of ephemeral interest. In addition to thanking the author, he would like those present to show their appreciation of the kindness of Lord Clinton in sparing so much of his valuable time to come and preside at the meeting.

Sir George Hart, K.B.E., C.I.E., in seconding the motion, said that Sir David Prain had already referred to the one point in the author's very able and interesting paper, to which he would have liked to draw attention. The author had shown on the screen pictures of the wonderful and remarkable way in which forest products were dealt with in British Columbia; but, to put it in quite plain English, he thought this amounted almost to forest destruction, as, indeed, the author had practically admitted. It was evident that British Columbia formed what might be termed the storehouse of the Empire for coniferous timbers, just as India, perhaps to a less extent, formed the storehouse of the Empire for hard wood timbers. India was conserving its forests and working them only to the extent to which they should be worked; but he feared that British Columbia had not yet adopted that policy. It seemed to him very important that attention should be paid to this point, because, if nothing was done to secure regeneration to the proper extent, it was quite certain that never again would the forests of British Columbia contain the same proportion of valuable timber as they possessed before they were cut down.

The resolution was carried unanimously.

MR. W. TURNBULL, in reply, said the Chairman had asked if he could give an estimate of the possible demand of this country on the timber of British Columbia. That was a very difficult question for him to answer. He thought the estimate could only be made by the men engaged in the timber industry in this country; he had asked them what the possibilities were and they said: "Give us the timber at our price and we will buy it." It was a matter of the price of the goods—a purely commercial question In 1919 British Columbia sent to this country some 47,000,000 ft. of timber, whereas in 1921 about 9,000,000 ft. were sent. He thought the latter figure was the normal amount sent just now: 47,000,000 ft was abnormal because it included timber bought as a war measure. Mr Corbett pointed out that Great Britain imported £120,000,000 worth of timber and timber products per year, and, as he had stated, British Columbia sent about 9,000,000 ft, which would be about 180,000 dollars' worth That might be some guide in forming an estimate, but he really could not attempt to make any estimate himself. It was purely a matter of commerce, and there was one point he would like to make in that connection The large, clear grades of timber that could not be obtained from Norway and Sweden could be sent to this country from British Columbia because they could stand the freight, and that timber represented 30 per cent. of the British Columbia product The common grades from that country would not, under normal conditions, carry the freight from the Pacific Coast to England If the people in British Columbia received an order from this country for 20,000,000 ft. of absolutely clear timber they would not accept it, because that would leave them with 40,000,000 ft. of common timber in their yards over and above their ordinary amount of common timber They would require to have an abnormal home market for common grades to the extent of 40,000,000 ft. if they were to supply this country with 20,000,000 ft. of clear wood A lumber manufacturer might be running a door factory—doors in Canada being made of clear stock, unpainted—and when business was good for clear timber that manufacturer would have to limit the quantity he would permit his door factory to use. He was very much interested in the Chairman's remarks about nomenclature. Personally, he avoided the botanical names as much as possible and kept to the trade names Even in the botanical names there were differences in different countries. For instance, the tree known as Douglas fir in this country was called *Pseudotsuga taxifolia* in British Columbia, and *Abies Douglasii* and *Pinus Douglasii* in this country Commercial men simply used the trade names. With regard to Sir David Prain's remarks about the use of valuable timber for making pulp to be used for an ephemeral purpose, strictly speaking, whenever timber was used for any commercial purpose it must be used for an ephemeral purpose. In the United States pulp was used for making the most beautiful furniture, basket chairs that closely imitated the Japanese wicker chairs, and twine, sacking and even clothing. He did not see any difference between using soft wood for such purposes and using it for street paving blocks. From an æsthetic standpoint it was a shame to cut down a single tree from the hills of British Columbia, but from the commercial point of view he could not see any difference between pulping it and sawing it into lumber or using it for any other commercial purpose. With respect to procuring timber from countries within instead of outside the Empire, that was purely a matter of business About six months ago he had a discussion with the manager of a company that controlled the buying of timber for paving the London streets, and so far as he could recollect that gentleman told him that the streets in the city of London consumed about 20,000 standards of Baltic timber a year That gentleman knew the Douglas fir and the Sitka spruce of British Columbia, and said: "If your lumber men can sell us their wood at a cheaper price than we pay for the wood from Norway, they will get my business" With reference to the amount of waste in the woods, a great deal of what was wasted was young growth that would not be commercially useful A hillside might look very much like the battle fields of France, but the waste appeared worse than it really was, as so much of it was stuff that was of practically no value It was a very difficult matter to control New logging regulations had been framed in British Columbia, and the intention was to adopt more conservative methods of cutting Only about one-fifth of the annual natural growth was cut, but the timber that was cut was mature timber, and there was no doubt that it would take a long time to replace that Afforestation was being studied in British Columbia, but it would be impossible to produce the old mature Douglas fir that nature had provided, although afforestation would ensure a really commercial type of forest If all the timber that existed at the present could be cleared off in about a hundred years' time and replanting carried out on the Swedish basis, more timber would be grown than could be cut. The logging men in British Columbia were very conservative, and if a logging superintendent was told that he ought to leave seed trees at certain points he would laugh at the idea, but both the logging men and the sawmill men had become much more interested in forestry than they ever were before. Commercial timber men had been brought to the stage when they realised that there was a real relationship between forestry and sawing lumber.

The meeting then terminated.

MR. C. M. RYAN, F.L.S., late India Forest Department, writes in support of Sir David Prain's views on the use of British Columbian timber for paper making :—

If there are grasses and shrubs already growing wild within the Empire and whose production can be increased by cultivation (as for instance, in India and Burma, which all who have studied the subject must admit) sufficient for the Empire's requirements, the use of valuable coniferous woods for this purpose, is to be deplored The trees that are being cut up and so manufactured not only in British Columbia, but in Newfoundland (where the paper making industry from soft wood is even larger) have taken over a century to grow, whereas grasses (excluding bamboos) and shrubs are producible in a year or two or three at the most. In seconding the vote of thanks to the reader of the paper on the subject of paper manufacture last year at a meeting of the Indian Section of the Royal Society of Arts, I mentioned that in India there exist untapped sources of wealth from fibres and grasses for paper manufacture, which ought to be developed. If efforts within the Empire in this and other directions were co-ordinated, which I take the liberty to suggest may be one of the first duties of the Empire Forestry Association, the wasteful sylvicultural methods in British Columbia so vigorously condemned by Sir David Prain, would probably cease.

OBITUARY.

SIR FREDERIC W. R. FRYER, K.C.S.I.- By the death, on February 20th, of Sir Frederic William Richards Fryer, late Lieutenant-Governor of Burma, the Indian Committee of the Royal Society of Arts loses a useful and valued Fellow Shortly after his retirement from the Indian Civil Service nearly two decades ago he read before the Society an admirable and comprehensive paper on Burma. At that time much was being heard of a demand for making Burma a Crown colony by uniting her to Ceylon and the Straits Settlements. Sir Frederic Fryer gave numerous reasons for his strong opinion that the province would really suffer instead of gaining by ceasing to be administratively part of the Indian Empire, even though constituted a separate Crown colony, nor could he see that it would be advantageous to her to be linked to the Straits Settlements or Ceylon.

He joined the Society in 1907 and in the same year was elected a member of the Indian Committee. Throughout his long connection with the Society he seldom missed an Indian meeting, taking the chair on more than one occasion and frequently contributing to the discussions.

Born in 1845 he was the son of Mr. F W. Fryer, of West Moors, Dorset, and received his education abroad as well as at the Bromsgrove Grammar School founded by Edward VI. A successful competitor in the Indian Civil Service Examination of 1863 he was posted in 1864 to the Punjab, where he acquired the reputation of an able and active frontier officer. He was transferred to Burma in 1886 for the purpose of assisting in the pacification of the territory annexed on the overthrow of King Theebaw and his services in that capacity marked him out for promotion. In 1895 he was appointed Chief Commissioner and in 1897 he became the first Lieutenant-Governor of Burma, retiring in 1903. Consequently he was head of the Administration for no less than eight years, a very unusual experience He was created a Knight Commander of the Star of India in 1895 while officiating as Financial Commissioner of the Punjab and occupying a seat in the Viceregal Legislative Council as an "additional member"

WILLIAM J. STARR, B A, LL B — Mr. William J. Starr of Eau Claire, Wisconsin, and Easton, Maryland, U.S A., died suddenly on December 13th, 1921. He was elected a Fellow of the Royal Society of Arts, in 1916 A graduate of Harvard University, Mr Starr was generally known as one of the leading naval architects in the United States but in addition to this he was a naturalist and an authority on trees and woods, and also a founder of libraries and a promoter of institutions of art and learning. Mr. Starr's business undertakings were varied and extensive. At the time of his death, he was President of two large manufacturing enterprises in Wisconsin He was the founder and president of a large orchard company and stock farm. He owned large tracts of timber land in California and swamp land, which was under the process of reclamation, in Louisiana. During his life he reclaimed over sixty-thousand acres of land in northern Wisconsin and it was largely through his efforts that Wisconsin now heads the list as a dairy state Mr. Starr lived upon a colonial estate in Maryland whose original land grant was made by Lord Baltimore in 1666. He was a distinguished member of many scientific societies and organisations, including the Committee of One Hundred for the Beautifying of Washington, The Deeper Waterways Commission, the Academy of Political Science, the Wisconsin Historical Society, the Sons of Colonial Wars. He was also a member of the New York Yacht Club, vice-commodore of the Chesapeake Bay Yacht Club, and a member of the Salmagundi Club, New York and Union League Club, Chicago.

NOTES ON BOOKS.

THE TIMES OF INDIA ANNUAL, 1922. Bombay: The Times Press, Rs. 2.

This beautifully got-up Annual affords striking evidence of the remarkable advance in printing that has taken place in India in recent years, and shows what fine work a well-equipped and properly organised press in that country is now able to accomplish. Pictorially and otherwise, the volume has been connected with the Royal visit, and the place of honour is given to an ode by Sir William Watson to the Heir Apparent:—

"Guest of this ocean-seated, mountain-crowned
Mother of half Earth's tongues"

Especially attractive are the numerous contributions, in pen as well as in pencil, of an old pupil of the late Sir Hubert Herkomer, R.A., Mr. Cecil L. Burns, ex-Principal of the Bombay School of Art, one of whose articles deals with "Indian Memorials in London Byways" An interesting account of the renaissance of Indian music is given by the Principal of the Baroda school of music, and the varied contents also include a story entitled "Two Terrors," by George Birmingham The addition of a list of contents would have been an improvement

THE MANUFACTURE OF STRINGED INSTRUMENTS AT NAGOYA.

Although stringed instruments adapted to European use were made in Japan in some quantity before the war, the enforced withdrawal of German competition abroad created an instant demand to which the Japanese manufacturer promptly responded, and though the export industry is of comparatively recent growth it has already assumed considerable proportions

From a report by the U S Consul at Nagoya, it appears that almost all of the stringed instruments exported, and the greater number of those of superior quality sold in Japan, are the product of one Nagoya house founded by Mr. Masakichi Suzuki, who in 1888 made his first violin, using as a model a foreign instrument brought to Nagoya as a curiosity. As a result of study and experiment the best grades of instruments now produced are said to bear favourable comparison with those of German make, whose place they have entirely taken in domestic and very largely in foreign (especially American) trade

The basic materials employed in making the instruments are Japanese maple and pine, which have been found admirably suited to this purpose. Other materials which it has been found necessary to import are fine hardwoods, such as Pernambuco wood, rosewood, mahogany, and ebony, from Brazil and India; ivory, also from India; horsehair from China, and sheep gut, principally from Australia.

Mr. Suzuki claims especial excellence for the finish of his instruments, which he attributes to the use of an oil varnish instead of the alcoholic varnish commonly applied. There are three Suzuki factories now in operation in Nagoya, with 1,100 employees.

In 1913, the year preceding the war, the total value of instruments and accessories produced was only about £5,000, of which about 8 per cent entered into the export trade; while in 1919 the value of production was about £108,000, of which almost 74 per cent. represents exports. Nearly 68 per cent. of the exports went to the United States. For the first six months of 1920 musical instruments to the value of about £61,000 were produced.

Mr. Suzuki believes that the Germans cannot manufacture instruments at Japanese costs, and that the instruments of Japanese manufacture having proved their good quality, in spite of prejudices which were at first entertained abroad, have now established themselves so firmly in foreign markets, and especially in the United States, that they cannot be displaced.

HAT INDUSTRY IN ARGENTINA.

There are 8 large factories and about 15 small shops in Buenos Aires devoted to the production of soft and stiff hats. The largest of these establishments employs between 200 and 300 persons, depending upon the season; the three next in size employ approximately 100 each, while the remainder have about 50 persons as a minimum

All operations are performed by each establishment, the larger ones even doing a part of their own cleaning, carotting, and cutting. The principal raw material used is hatters' fur, and the skins are mostly those of the native winter hare Rabbit skins are employed to a limited extent, but nutria, castor, and other furs are seldom touched. There are also independent fur cutters, whose product is not high grade, and therefore has little demand, except for mixing with better fur to produce a cheaper hat.

According to a report by the United States Trade Commission in Argentina, previous to 1914, very little hatters' fur was actually prepared within the country, it having been more economical and generally satisfactory to import the blends or types required from Europe and the United States. The experience of the last few years has proved that the fur can be produced quite well at home, and it is therefore likely that the industry will continue. Although the greater part of the fur is brought in, the total requirements can only be approximated, since no accurate statistics are available regarding either the amount imported, the amount prepared locally, or the number of hats turned out. Estimates of the latter place the total output at 110,000 to 125,000 dozens yearly.

Each hat requires from 110 to 115 grammes of fur. One of the large manufacturers carries on hand a stock of 14 to 15 tons of blown fur. In this quantity are represented many kinds of furs, but ordinarily any of the standard mixtures or types are satisfactory.

Hardening and sizing are carried on by hand or machinery, according to the type or quality of the finished hat. These machines, as well as the blowers and forming machines, are usually of English make. Machines for other purposes are brought from Italy, the United States, or whichever country happens to be foremost in a particular line, the larger factories being quite as well equipped as the average establishments in any other part of the world.

The goods turned out are of excellent quality, except in those cases where low-grade hats are made intentionally.

Sweat bands are made by several small shops, but on account of their poor quality are used only for the cheaper hats. The British makes are the most popular of the imported bands, some 75 per cent. coming from England as against 22 per cent. from the United States. The market is not confined to the fur felt hat factories, but embraces also the manufacturers of straw hats, cloth hats, caps, and military and police helmets. Silk bands, ribbons and lining materials come from France and Italy. Other accessories, such as sewing thread, sandpaper for pouncing, dyes and shellac are usually purchased in the open market.

GENERAL NOTES.

Royal Institute of British Architects.—Mr. Thomas E. Collcutt, Past President of the Royal Institute of British Architects, has organised a competition for young architects and architectural students, who are to prepare designs for a business building facing on an ordinary London street, in which "colour" of a permanent nature is to be the dominant feature. The judges in the competition will be Mr. Collcutt himself, Sir Edwin Lutyens, R.A., and Professor Gerald Moira, of the Royal College of Arts. The sum of £200 has been handed to the President of the Royal Institute of British Architects by an anonymous donor to provide prizes for this competition. The first prize will be £100, and there will be other prizes of £50. £30 and £20. The designs submitted will be exhibited at the Royal Institute after the close of the competition.

Indian Timbers and Paper Materials.—Enquiries into the possibility of increasing the utilisation of Indian timbers in this country and of making use of Indian paper materials have been carried out in connection with the Indian Trade Enquiry undertaken by the Committee for India of the Imperial Institute, and the reports have just appeared in a volume published by Mr. John Murray under the title "Reports on Timbers and Paper Materials" (price 4s.). Hitherto the exports of timber (other than teak) from India have been relatively small, owing chiefly to the existence of a large local demand. It is considered, however, that there would be an opening for an extended export trade to the United Kingdom in certain hardwoods, which would be of value for decorative and other purposes, and are at present little known in this country. The characters and uses of a number of such timbers are described. In the section on paper materials, a general statement is given as to the world's pulp and paper-making industry, special reference being made to the position in India. Details are included as to the possibility of utilising Indian bamboos and savannah grasses for paper-making, and the opinion is expressed that in these two materials India possesses valuable resources which occur under circumstances not unfavourable for their commercial development. It is considered that the immediate aim in the developments of an Indian paper-pulp industry, which should receive every encouragement from the Government of India, should be to reduce, and finally replace (as far as possible) by Indian supplies, the large amount of pulp and paper imported into that country. It is believed that the replacement of imports by Indian produce would be quickly followed by a surplus production which would be available for export.

Cinnamon.—The current number of the *Bulletin* of the Imperial Institute contains an article on cinnamon, its sources, production and trade, giving a detailed account of the production of the bark in different parts of the Empire, as well as in foreign countries, and a description of the aromatic oils yielded by cinnamon and related trees. The finest cinnamon bark is produced in Ceylon, where the Portuguese found the tree growing wild when they arrived in the island in 1505. Since that date Ceylon has been famed for this spice, but owing to the small financial return it gives to the growers, much of the area under cinnamon in the island has been replaced by the more profitable coconut and Para rubber. Ceylon cinnamon, moreover, has had to compete, particularly in the Continental markets, with a cheaper product of coarser flavour from the Far East. Cinnamon bark reaches this country in two forms: the ordinary "quills," used as spice, and "chips," which are distilled for the production of cinnamon oil used in medicine. The leaves of the cinnamon tree yield an entirely different oil from that of the bark: this oil contains eugenol (the characteristic constituent of oil of cloves) which is employed in the manufacture of vanillin, the well-known flavouring agent. Cinnamon leaf oil is produced largely in the Seychelles.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, MARCH 6.. People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Robert Armstrong Jones, "Fatigue and Sleep."

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Prof. W. Somerville, "The Improvement of Poor Pasture."

Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.

Geographical Society, 131, New Bond Street, W., 8.30 p.m.

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Mr. W. Cullen, "Gold Metallurgy of the Witwatersrand, Transvaal."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Mr. E. Ambrose, "E.H.T. Cable Testing." (Western Centre), Merchant Venturers' Technical College, Bristol, 6.30 p.m. Mr. L. H. A. Carr, "Induction-Type Synchronous Motors."

TUESDAY, MARCH 7.. Royal Institution, Albemarle Street, W., 3 p.m. Sir Arthur Keith, "Anthropology of the British Empire." (Lecture III.)

Royal United Service Institution, Whitehall, S.W., 3 p.m. Anniversary Meeting.

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. M. Thiery, "Le Théâtre de Meilhac et Halvéy."

Alpine Club, 23, Savile Row, W., 8.30 p.m.

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. C. W. Milne, "On the Trail in Mexico."

Electrical Engineers, Institution of (E. Midland Centre), Technical College, Derby, 7 p.m. Mr. J. F. Driver, "The X-Ray Examination of Materials." (N. Western Centre), College of Technology, Manchester, 7 p.m. Dr. C. C. Garrard and Mr. F. Gill, "Exhibition of Cinematograph Films."

University of London, Royal School of Mines, Imperial College, South Kensington, S.W., 5.30 p.m. Colonel N. T. Belaiew, "The Crystallisation of Metals." (Lecture III.) At the London School of Economics, Houghton Street, Aldwych, W.C., 6 p.m. Sir Josiah Stamp, "The Administrative Factor in Government." (Lecture IV.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Scientific and Technical Meeting.

WEDNESDAY, MARCH 8. Royal Society for the Prevention of Cruelty to Animals, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Major-General Sir L. J. Blenkinsop, "The Problem of Horse Traffic on Modern Road Surfaces."

Royal United Service Institution, Whitehall, S.W., 3 p.m. Colonel W. M. St. G. Kirke, "The Development of Communications in the Middle East and their Strategic Importance."

Metals, Institute of, at the Institution of Mechanical Engineers, Storeys Gate, S.W. (Morning Session, 10 a.m. to 1 p.m.) (1) Annual General Meeting. (2) Dr. G. D. Bengough, "Notes on the Corrosion and Protection of Condenser Tubes." (Afternoon Session, 2.30 p.m. to 4.30 p.m.) (1) Mr. F. Adcock, "The Internal Mechanism of Cold-Work and Recrystallization in Cupro-Nickel." (2) Major C. J. Smithells, "The Effect of Impurities on Recrystallization and Grain Growth." (3) Messrs. H. Moore and S. Beckinsale, "Further Studies in Season-Cracking and its Prevention. Condenser Tubes."

University of London, King's College, Strand, W.C., 5.15 p.m. Prof. Nils Bohr, "The Quantum Theory of Radiation and the Constitution of the Atom." (Lecture I.) At the London School of Medicine for Women, Hunter Street, W.C., 5 p.m. Dr. H. H. Dale, "Some Recent Developments in Pharmacology." (Lecture III.)

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Sheikh Abdel Razek, "The Mosques of Cairo."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Professorial Lecture.

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Miss B. Voysey, "The Personal Factor in Industry."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Prof. S. L. Cummins, "The Clinical Differences in the Course of Tuberculosis seen in various Age Groups and Races."

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Mr. A. A. Remington, "The Design and Function of Laminated Automobile Suspension Springs."

THURSDAY, MARCH 9. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. L. F. Newman, "The Law Temperature Research Station at Cambridge."

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Historical Society, 22, Russell Square, W.C., 5 p.m. Miss G. Whale, "The Influence of the Industrial Revolution (1760-1790) on the Demand for Parliamentary Reform."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Miss Coombs and Mrs. Bottrill, "The Family Group System in Infant Schools."

Optical Society, Imperial College of Science, South Kensington, S.W., 7.30 p.m.

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m. Air-Commodore H. R. M. Brooke-Popham, "Some Notes on Aeroplanes, with special Reference to the Cross Desert Route from Cairo to Baghdad."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. H. M. Lefroy, "Insect Pest Control." (Lecture II.)

Anglo-French Society, Scala House, Tottenham, Street, W., 6.15 p.m. M. Emile Cammaerts, "La poésie moderne de la langue Française." (Part I.)

Faraday Society and the Oil and Colour Chemists Association (Joint Meeting), at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m.

Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 10 a.m. Annual Meeting continued. (1) Prof. C. A. Edwards and Mr. A. J. Murphy, "The Rate of Combination of Copper and Phosphorus at Various Temperatures." (2) Dr. W. Rosenhain, Note on "Some Cases of Failure in 'Aluminium' Alloys." (3) Prof. F. C. Thompson and Mr. E. Whitehead, "Some Mechanical Properties of the Nickel-Silvers." (4) Dr. D. Hanson and Marie L. V. Gayler "A Further Study of the Alloys of Aluminium and Zinc." (5) Mr. A. Westwood, "The Assay of Gold Bullion."

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Dr. L. D. Barnett, "The Hindu Culture of India." (Lecture II.)

Dyers and Colourists, Society of (Bradford Junior Branch). Mr. H. Winslow, "The Franklin Dyeing Process."

FRIDAY, MARCH 10.. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Captain L. Thompson, "The Open Air Life of London."

Royal Institution, Albemarle Street, W. 9 p.m. Prof. T. R. Merton, "The Variability of Spectra."

Metals, Institute of, at the Sir J. Cass Technical Institute, Jewry Street, E.C., 8 p.m. Dr. D. Hanson, "Micro-structure and Physical Properties of Alloys."

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W.

Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.

Electrical Engineers, Institution of (Irish Centre) Royal College of Science, Dublin, 8 p.m. Prof. R. Stanley, "Wireless Communication in the Campaign in France."

SATURDAY, MARCH 11.. Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Radio-Activity." (Lecture II.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 273

Journal of the Royal Society of Arts.

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FRIDAY, MARCH 10, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 15th, at 8 p.m. (Ordinary Meeting.) OSWALD T. FALK, "Certain Aspects of the Problem of Exchange Stabilisation." SIR ROBERT M. KINDERSLEY, K.B.E., in the Chair.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 1st, 1922; Mr. Percy A. Scholes, Music Critic to the *Observer*, in the Chair.

The following candidates were proposed for election as Fellows of the Society:

Donald, Bernard Speirs, London.
Seago, Miss Muriel, Harrogate

The following candidate was balloted for and duly elected a Fellow of the Society:-

Armstrong, Frederick William, Manchester.

A paper on "The Duplex Coupler Pianoforte" was read by Mr. Emanuel Moor.

The paper and discussion will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

On Monday evening, March 6th, PROFESSOR ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., delivered the third and final lecture of his course on "The Mechanical Design of Scientific Instruments."

On the motion of the Chairman, SIR HERBERT JACKSON, K.B.E., F.R.S., a vote of thanks was accorded to Professor Pollard for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1922 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 25th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R S.
1868, Sir Joseph Whitworth, LL D., F R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F R S.
1873, Michel Eugène Chevreul, For Memb. R.S.
1874, Sir C. W. Siemens, D.C.L., F.R S.
1875, Michel Chevalier
1876, Sir George B. Airy, K C.B, F.R.S.
1877, Jean Baptiste Dumas, For. Memb. R.S.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S
1879, Sir William Thomson (afterwards Lord Kelvin), O.M, LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D, LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C S I., C.B., M.D., D.C.L., LL.D., F.R.S
1884, Captain James Buchanan Eads
1885, Sir Henry Doulton
1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, HER MAJESTY QUEEN VICTORIA.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt, F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.

1894, Sir Joseph (afterwards Lord) Lister, F.R.S

1895, Sir Isaac Lowthian Bell, Bt., F.R.S.

1896, Professor David Edward Hughes, F R S.

1897, George James Symons, F R.S

1898, Professor Robert Wilhelm Bunsen, M.D., For. Memb. R.S

1899, Sir William Crookes, O M, F R S

1900, Henry Wilde, F R S

1901, His Majesty King Edward VII

1902, Professor Alexander Graham Bell

1903, Sir Charles Augustus Hartley, K C M G.

1904, Walter Crane

1905, Lord Rayleigh, O.M, D C.L, Sc D. F R S.

1906, Sir Joseph Wilson Swan, M A, D Sc, F.R S

1907, The Earl of Cromer, O M, G C B. G.C.M.G., K C S.I, C.I E.

1908, Sir James Dewar, M A, D Sc, LL D, F.R S.

1909, Sir Andrew Noble, K C B, D Sc, D C.L, F.R S

1910, Madame Curie

1911, The Hon. Sir Charles Algernon Parsons, K.C B, LL D., F.R S

1912, The Right Hon Lord Strathcona and Mount Royal, G C M G, G C V O, LL D, D C L, F.R S

1913, His Majesty King George V

1914, Chevalier Guglielmo Marconi, G C V O. LL D., D.Sc.

1915, Sir Joseph John Thomson, O M, D Sc, LL D, F.R.S.

1916, Professor Elias Metchnikoff

1917, Orville Wright

1918, Sir Richard Tetley Glazebrook, C B. Sc.D, F.R S

1919, Sir Oliver Joseph Lodge, D Sc, LL D. F R S

1920, Professor Albert Abraham Michelson For Member, R.S

1921, Professor John Ambrose Fleming, D Sc. F R S.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

Wednesday, February 8th, 1922.

Owing to the unavoidable absence of Sir Arthur Duckham, the Chair was taken by Mr. W. J. U. Woolcock, C.B.E., M.P.

The Paper read was :—

SOME SOLVED AND UNSOLVED PROBLEMS IN GAS WORKS CHEMISTRY.

By E. V. Evans, F.I.C.

Having chosen so comprehensive a title for a short paper, it will be possible to select only a few of the many problems which present, or have presented, themselves to the gas chemist, and this selection is made almost at random.

Naphthalene.

It is the duty of a gas undertaking to supply to its consumers a gas reasonably constant in composition and uninterruptedly adequate in quantity. In order to carry out this requirement of adequacy of supply, it is necessary from time to time, as the business of the gas undertaking increases, to augment, up to a certain point, the pressure at which the gas is supplied, or to relay the mains and services which have become incapable of dealing with the increased volume of gas. This is a question for the engineer. Gas engineers have been much harassed in the past by naphthalene, which separates out in a solid form from coal gas and reduces the carrying capacity of the mains and services. This is a question for the chemist, who is hardly justified in studying the more interesting questions of the retort house or of the efficiency of gas appliances, if the gas manufactured cannot, without interruption, be relied upon to reach the consumer's appliances owing to naphthalene stoppage. The naphthalene problem does not to-day fall under the category of the unsolved.

Before proceeding to describe one method which it is suggested solves the naphthalene problem, it is unfortunately necessary to emphasise the fact that gas technologists have been led astray in the past as a result of relying upon certain naphthalene vapour pressure determinations made by Allen in 1900. From his determinations it would be inferred that wet coal gas at the freezing point of water is saturated by six grains of naphthalene per 100 cu. ft.; but recent investigation by Dr. J. S. G. Thomas has shown that this is incorrect, and that saturation is attained with only 0.8 grains of naphthalene per 100 cu. ft. (Fig. 1.) The original investigator's curve is correct for temperatures above about 90° F., but his results are misleading over the temperature interval, which is of the greatest interest to gas engineers. These determinations of vapour pressure refer to the weight of naphthalene that saturates the gas under varying conditions of temperature, and are made by ascertaining the weight of naphthalene existing as vapour when gas is in contact with an excess of solid naphthalene. It does not follow that

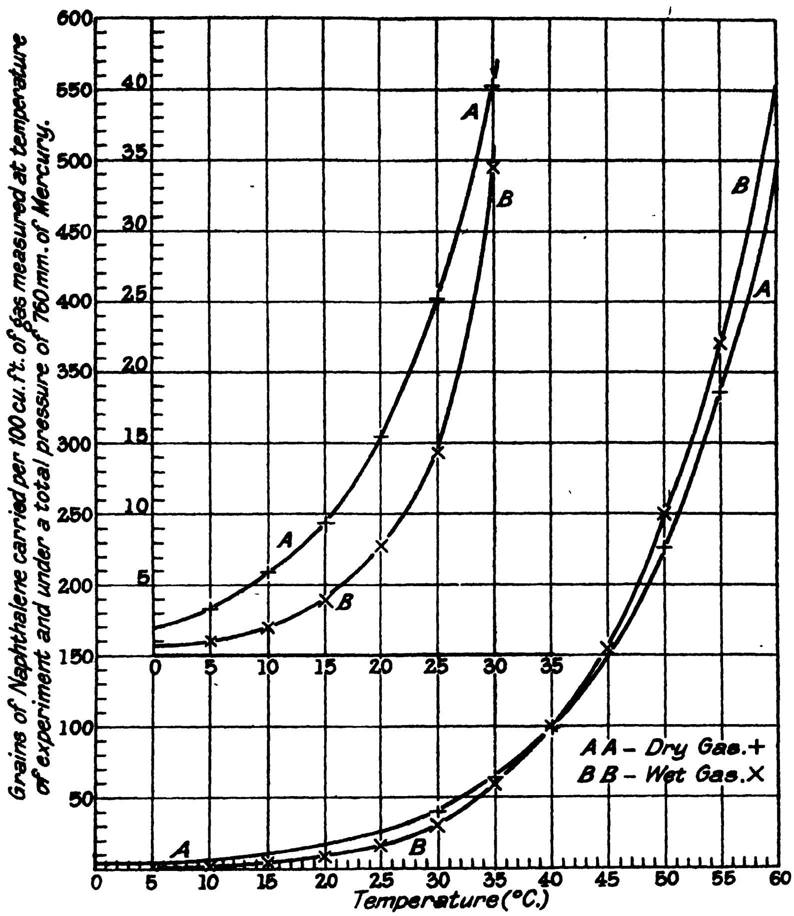


FIG. 1.

the gas is incapable, under certain conditions, of retaining as naphthalene vapour quantities greater than those indicated by the curve. This aspect of the question, which is a highly complex one, has not been studied; the deposition of naphthalene is influenced by the state of motion of the gas, the rate of change of temperature and probably also by the nature of other hydrocarbons present. Owing to the absence of precise knowledge of the conditions which govern the deposition of naphthalene from coal gas, the question has been referred to as the "Naphthalene Bogey," and would frequently seem to be regarded as phenomenal. Naphthalene deposition is indeed so complex that there exists a school of gas technologists who believe that, to gain perfect immunity from annoyance, all naphthalene should be extracted from the gas before it leaves the works for distribution. By complete extraction of naphthalene is meant that the gas passed through an aqueous solution of picric acid at the rate of 1 cu. ft. per hour for 24 hours gives no precipitate, or perhaps so little that it is unweighable on an ordinary chemical balance.

Now, ordinary anthracene or heavy oil resulting from the distillation of coal tar is an efficient solvent for naphthalene; but the oil, as ordinarily distilled, itself contains naphthalene and is thus unsuitable for the complete extraction of this hydrocarbon from gas. If, for example, air be drawn through a sample of anthracene oil, it will be seen that a copious precipitate is obtained by washing that air subsequently with an aqueous solution of picric acid. (Experiment). Bueb, in Germany used this medium for naphthalene washing in 1902, but the washed gas contained from 3 to 4 grains of naphthalene per 100 cu. ft., and reference to the vapour pressure curve will

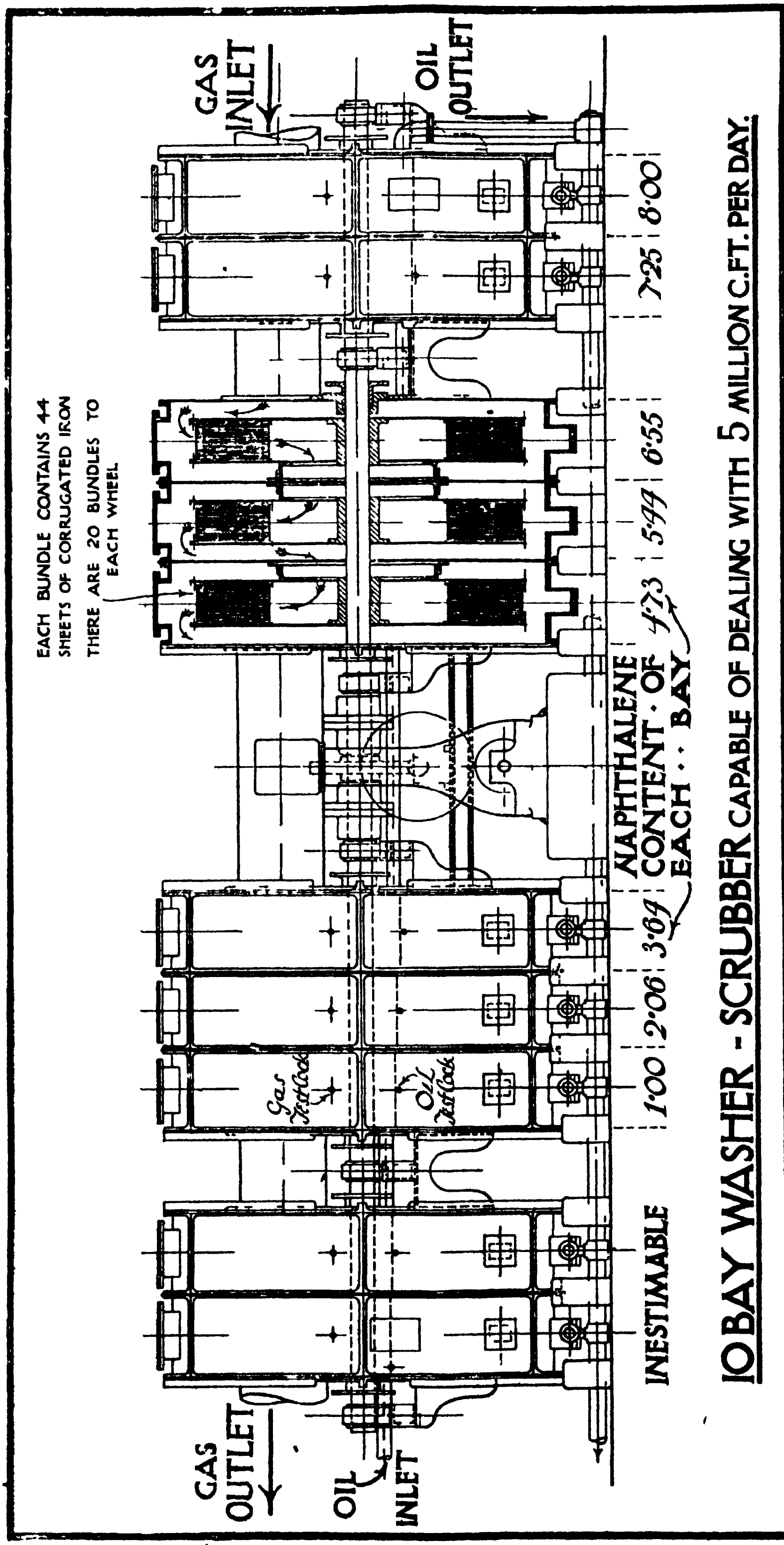

GAS INLET
OIL OUTLET
EACH BUNDLE CONTAINS 44 SHEETS OF CORRUGATED IRON
THERE ARE 20 BUNDLES TO EACH WHEEL
NAPHTHALENE CONTENT OF EACH BAY
INESTIMABLE
1·00
2·06
3·64
4·73
5·44
6·55
7·25
8·00
Gas Test Cock
Oil Test Cock
GAS OUTLET
OIL INLET
10 BAY WASHER - SCRUBBER CAPABLE OF DEALING WITH 5 MILLION C.FT. PER DAY.

FIG. 2

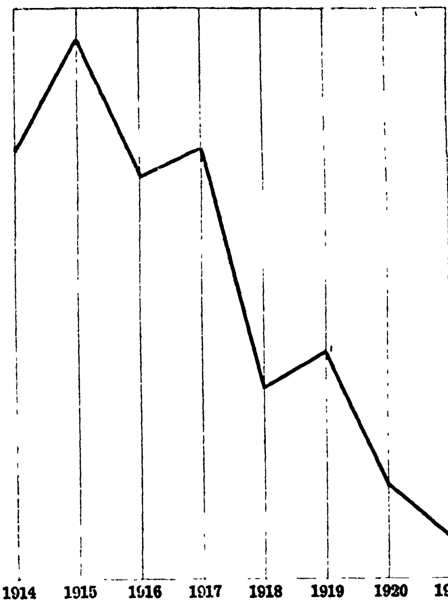
show that this quantity represents the saturation point of wet gas at 13°C. (55°F.) If, however, the oil be steam distilled before use and then applied systematically to the gas stream in a compartment washer-scrubber, the complete extraction of naphthalene may be effected. Now, an equal quantity of air to that used in the previous experiment, when drawn through steam distilled oil is seen to give no precipitate with aqueous picric acid. (Experiment). This oil is used in a washer-scrubber of 10 bays (Fig. 2) and flows in counter direction to the gas at the rate of about about 15 gallons per million cu. ft. of gas. The spent oil flowing from the final bay possesses a concentration of 6 to 8% of naphthalene and the concentration decreases in each bay until in the oil inlet bay it is practically free from naphthalene. (Fig. 2). The amount of oil used is that required to remove completely the naphthalene from the gas; and the figure quoted above is an average one. The cost of operating the process is shown in Fig. 3.

WORKING COSTS OF NAPHTHALENE EXTRACTION.

Item.	Per 1000 c. ft.	Per 10 Therms.
	Pence.	Pence.
Oil used...	.1059	.189
Wages	.0105	.019
Power	.0196	.035
Repairs and maintenance and sundries	.0044	.008
	.1404	.251
Interest on capital ...	.0285	.051
Establishment charges...	.0122	.022
	.1811	.324

FIG. 3.

This process in the case of the South Metropolitan Gas Company, extracts about 130 tons of napthalene annually. The effect upon the business of a gas undertaking is shown by the curve in Fig. 4, which represents the decrease in the total annual number of naphthalene complaints received from consumers during the last few years. This diagram is given solely to demonstrate the slope of the curve, which is a *bona fide* one; numerical values are



Curve showing fall in Naphthalene Complaints 1914-21

FIG. 4.

not given. Although the attainment of 1921 is not far from the zero line, it may still be some little while before this ideal, representing complete freedom from naphthalene complaints is reached, as there must still exist some naphthalene left in the smaller and less used services as a heritage of former years.

SULPHUR COMPOUNDS.

It is not proposed to deal at any length with the subject of the removal of sulphur compounds from gas. It is, however, of interest to state that Dr. Carpenter has, within recent times, considerably improved and simplified the nickel catalytic process; and it is to be hoped that he will communicate to the gas industry the nature of this work when it is completed.

Upon the subject of carbon bisulphide, one observation has recently been made which is particularly suitable for lecture demonstration. An enquiry into the causes which determine the fluctuation of the flow of gas and consequent unreliability of certain byepass tubes adjacent to the inverted incandescent burner, showed that the gas flowing through the byepass tube during the lighting period of the burner is raised to such a temperature that there exists within the tube a miniature sulphur removal process. The conditions are here

reproduced [Experiment] whereby it is seen that gas, after passing through a heated byepass tube adjacent to an inverted burner, contains hydrogen sulphide, as shown by the brown colouration of lead acetate paper. A control burner carrying an unimpregnated paper shows a negative result. In the heated byepass tube, carbon bisulphide in the gas is undergoing decomposition with the production of hydrogen sulphide and the deposition of carbon; and this deposited carbon, together with the metallic sulphide produced, is one of the contributing factors to the inefficiency of this form of byepass. The difficulty may be overcome by designing the burner and byepass in such a way that the latter does not become heated, or by making that portion of the tube liable to be heated of pipe clay or other suitable insulating material.

HYDROGEN SULPHIDE.

The method of removing hydrogen sulphide from coal gas by means of oxide of iron, though almost universally practised to-day by gas undertakings, is an ancient process. The chemist has been unable to recommend an alternative, so trustworthy and economical, as to render the present obsolete. In the ideal process the value of the recovered sulphur or sulphuric acid should be at least equal to, if not greater than, the cost of operating the process. It is one thing to create an ideal and another to accomplish it, and it is believed that this problem still falls under the category of the unsolved. The present method is not only a financial burden to the gas undertakings, but it is also open to criticism in other respects. The physics of the process is unsound in that a gaseous impurity at an initial concentration of 1 per cent. by volume is extracted by means of a solid reagent. Again, the expenditure involved in handling large masses of solid oxide of iron in times of high labour costs accentuates the advantages that must accrue by discovering a simple process based on the use of a liquid reagent. Further, the presence of small quantities of hydrogen cyanide in the gas results in the formation of ferrocyanides which renders a proportion of the iron inactive during each cycle, and leads to the oxide becoming prematurely inactive. Finally, the efficiency of the oxide depends to a large extent on its physical nature and its selection is a matter of considerable importance.

To avoid excessive labour costs due to the handling of large masses of solid material and to allow of the selection of a rapid yet simple reaction uninfluenced by other constituents of the gas, the tendency in recent years has been to develop a wet method of purification in which solutions or suspensions may be dealt with by pumping machinery.

The fundamental reaction upon which by far the majority of the purification processes invented are based is that of the oxidation of hydrogen sulphide to water and sulphur.

$$2H_2S + O_2 = 2H_2O + 2S$$

This is indeed the resultant reaction of the iron oxide process, the hydrated ferric oxide merely acting as an intermediary which reacts with the hydrogen sulphide in the gas and is regenerated by contact with air, either in situ or externally. In viewing the reaction from this aspect and knowing also the ease with which hydrogen sulphide combines with oxygen, it is natural that the first attempt to discover a simple process would lie in the direction of endeavouring to oxidise the hydrogen sulphide in the coal gas mixture by a process of preferential combustion. Thus the experimental work would consist in conducting coal gas, firstly, over oxidising materials, which, at slightly elevated temperatures, would effect this reaction, or adding to the gas such a proportion of air or oxygen and then passing the mixture over a contact or catalytic substance, again at slightly elevated temperature, to promote the preferential combustion of hydrogen sulphide to sulphur and water vapour. If this reaction could have been induced to proceed satisfactorily it would not have been a difficult matter to remove the condensed sulphur by means of either filtration or electrical precipitation. A careful study of the properties of a large number of oxides was made but attempts to oxidise preferentially the hydrogen sulphide of coal gas, either by heated oxides or by the addition of air in the presence of a contact material or catalyst have been unsuccessful. In the first place, it is most difficult to prevent the oxidation of certain other constituents of the coal gas mixture; but the outstanding difficulty lies in the fact that a secondary reaction takes place when coal gas containing hydrogen sulphide is heated. Carbon oxysulphide resulting from the interaction of carbon monoxide and sulphur is the main

product of this side reaction. It escapes easily from the reaction zone and is a sulphurous compound more difficult to remove than hydrogen sulphide. It serves no good purpose to describe in any detail partly finished experimental work which has given negative results. Although finality is not reached, from the evidence at present acquired it would appear that a satisfactory solution of the problem is not to be found upon these lines. It is interesting to note that, in patents recently taken by Bayer & Co., and others, this reaction of the oxidation of hydrogen sulphide is caused to take place by means of contact of the gas with highly porous material such as charcoal. After such treatment, however, very few illuminants remain in the gas mixture, and, although these may probably be recovered at a reasonable cost, such a treatment is a very drastic one.

A more hopeful line of investigation for the solution of this problem would appear to lie in the use of oxidants in the cold, as not only is the cost of heating the gas avoided but the secondary reaction referred to above is obviated. The ideal oxidant should give on reduction by means of hydrogen sulphide in the gas a soluble product capable of easy regeneration to the original compound by the passage of air through the solution. The sulphur would then be the only material remaining out of solution and could be filtered off in a practically pure state. A fairly complete study has recently been made of inorganic and organic oxidants. It is only possible at this stage to demonstrate a typical organic reaction which has recently been protected by patent. It is well known that certain dyestuffs are readily reduced to colourless or faintly coloured products known generally as leuco-compounds which, in turn, are easily re-oxidised to the parent dyestuff. Indigo, for example, is insoluble but gives a soluble reduction product (indigo white). The dye is fixed upon the fibre by immersion of the fabric in the soluble leuco-compound, and then by subsequent exposure of the fabric to air, the fast colour is produced. It was found that hydrogen sulphide of gas is capable of effecting the reduction of certain dyestuffs which, in turn, re-oxidise to the original dyestuff by the passage of a current of air. The sulphur naturally remained out of solution. Investigations were made to discover those dyes which are both soluble themselves and have soluble leuco-compounds so as to obtain the ideal type of oxidant. (Soluble dyes forming insoluble leuco-compounds can be used, but their reduction products require a large and unreasonable excess of air for their oxidation.) Unfortunately, few dyes of the required type could be found.

The reduction of such dyes by hydrogen sulphide in neutral solution proceeds, if at all, only very slowly, and consequently an accelerator has to be used in the form of some basic substance. Alkali carbonates and bicarbonates are very effective for this purpose, but, unfortunately, so much sulphur is lost owing to the formation of salts of polythionic acids, that the use of such compounds is prohibitive. Turning to the organic bases as accelerators, pyridine and allied compounds are found to give the best results since other types frequently undergo gradual oxidation during the aeration process, with consequent conversion to inactive substances. Pyridine is especially suitable since pyridine water mixtures act as solvents for certain leuco-compounds otherwise insoluble in water, e.g., leuco-methylene blue. The use of this solvent allows therefore a wider choice of dyestuffs. With such an organic base as promoter no loss of sulphur occurs; but unfortunately pyridine, owing to its high volatility, cannot be used in the gas stream without also installing a recovery plant. Higher boiling basic coal tar fractions of the quinoline series may also be used; but these necessary refinements materially alter the simplicity and financial aspect of the process, and, up to the present, interesting though the chemical aspect of these reactions may be, it has not been possible to recommend the abolition of oxide purification. Other processes that have from time to time been proposed for the displacement of oxide of iron do not present the simplicity of such oxidation reactions as those indicated above; and it is to be hoped that before long it will be possible to report success along these lines, effected either by inorganic or organic reagents. The indications of to-day are not unfavourable.

Tobacco Smoke.

Following a dissertation upon vat dyestuffs, it is thought that a diversion on tobacco smoke will be welcome. The aim and object of this diversion is to discuss

the question of risks. Statistics will show that by travelling to the Adelphi to-night each of us has incurred risk of death, that each day we risk death or accident by transit, ptomaines, food preservatives, disease and many other unwholesome things, including even a possible death from coal gas by carbon monoxide poisoning. To be alive is indeed to be subjected to a series of risks, but it is necessary, above all things, to maintain a due sense of proportion of such risks; and statistics will show that death by accidental gas poisoning constitutes an almost negligible risk to the community. Now, the chemist is unfortunately able to detect dangers that others fail to see. About 90 per cent. of our manhood smoke, and I propose to show you what risks are involved in this pleasant operation of smoking. [The Lecturer here lighted and smoked a cigarette.] Its risks are really negligible, the process of smoking having proceeded without any apparent harm since the days of Raleigh. Notwithstanding this, the chemist can scare the public, if he so wishes, on this question of smoking, and upon many others. Parliament has decreed that coal gas shall be free from hydrogen sulphide, and has instituted a severe test, in which the gas is passed over papers previously immersed in lead acetate solution. It will be seen that the lead paper in the cigarette holder has already turned brown, showing the presence of hydrogen sulphide, whilst the second control paper, not previously immersed in lead acetate solution, shows no colouration. (It may have been thought that the colouration was due to tarry matter deposited from the smoke.) Now, the quantity of hydrogen sulphide is exceedingly small, and the risk is probably negligible, yet the chemist has to remember that hydrogen sulphide which is undoubtedly drawn into the mouth when smoking, is appreciably more toxic than carbon monoxide, and in addition to this, is a cumulative poison. This, however, is not the sole toxic constituent of tobacco smoke; it may be demonstrated that carbon monoxide and hydrogen cyanide (prussic acid) are also present. There is here a small apparatus for producing tobacco smoke. The process of smoking is partly one of combustion, partly carbonisation, and the plant resembles a miniature gas works. A retort house of cigarettes leads to a condenser packed with glass wool for the purpose of arresting tarry matter; the gases are then washed by an alkaline solution for the purpose of removing hydrogen sulphide and hydrogen cyanide, then by an acidified solution for the purpose of removing alkaline constituents of the smoke. The gases are then measured and are collected in the sample holder. The exhauster is the gas holder, which has to be operated intermittently following the method of cigarette smoking. It is in this apparatus that some of the determinations have been made which allow of subsequent statements. The time taken in working this apparatus is too long for a lecture-demonstration, but in order to prove the presence of the toxic substances in tobacco smoke a Havana cigar is now being smoked through a purifying apparatus, which consists, firstly, of a wash bottle of caustic potash for the purpose of arresting hydrogen sulphide and hydrogen cyanide; secondly, of a loosely packed tower of soda-lime, and finally, through a solution of bullock's blood. It is shown, even after a short period of smoking the cigar, that both hydrogen sulphide and hydrocyanic acid are present in the caustic potash, whilst the characteristic change of colour in the blood solution is indicative of the presence of carbon monoxide. Tobacco smoke contains quite appreciable quantities of the toxic gas, carbon monoxide. It has been found, for example, that the smoke from a cigarette contains up to 1½ per cent., whilst that from a cigar smoked irregularly contains up to 7 per cent. Assuming that carbon monoxide is not absorbed by the membranous coating of the mouth, it may be shown that with four people smoking cigars in one room the carbon monoxide contained in the air is liable to be equivalent to an escape of gas which would certainly be obvious to the olfactory organ.

During last year, a Committee appointed by the Board of Trade, under the Chairmanship of Sir William Pearce, reached the important conclusion that no limit should be placed upon the percentage of carbon monoxide to be contained in the gas distributed to the public. This Committee was fully alive to the toxicity of carbon monoxide, and to the responsibility it may be called upon to take by arriving at this decision, but it is suggested to you that to be read into its decision is its belief that the gas industry is now equipped with men of science at the University of Leeds,

South Kensington and other centres, and the safety of the public can be entrusted to the gas undertakings. The chemist will play an important role in deciding upon any change that, for economic reasons, may warrant an alteration in the constitution of the gas supplied. The Institution of Gas Engineers has shown itself to be fully capable of conducting, with the aid of the University of Leeds, careful and comprehensive investigations into matters affecting the fundamental principles of gas manufacture, and the public may rely upon such a body continuing to protect their interests on the question of carbon monoxide.

Reverting again to these demonstrations upon smoking, I should like to add that, personally, although an ardent smoker, I think that the habit is a dangerous one, and causes more harm than does coal gas. Notwithstanding the risks to which one is subjected when smoking, I do not propose to discontinue it—preferring the risks. Neither is it my object to start a press campaign to depopularise smoking. The example is chosen solely to demonstrate how simple it is for the chemist to elaborate upon the question of the unknown risks of life. Whilst we must not shut our eyes to the engineering and chemical disabilities which may arise from unduly increasing the carbon monoxide content of gas, yet I should like to take this opportunity of urging the press and the public to retain a sane and balanced conception on the question of risk.

SMOKELESS FUEL.

For many years the German dye industry has adopted the practice of manufacturing a colour of high purity—in some cases reaching 100 per cent. chemical purity—and before sale have slightly diluted their product with a harmless material. This practice is not resorted to for the purpose of defrauding the customer, but it allows a manufacturer to become assured that each delivery from the works shall be consistent as regards the quantity of colour contained in it. The dyer knows, and implicitly relies upon the fact, that each unit weight of material taken by him will have the same dyeing effect. If there is one thing above all others that the chemist attached to the chemical industry soon learns to appreciate, it is the necessity of maintaining the output of a consistent product. The tar distiller supplying anthracene, naphthalene, carbolic acid, etc., for the chemical market, has to work to a well defined specification. Naphthalene, for example, to realise full market price, must have a setting point of 79.5° to 79.6°C., and must, above all, have the appearance of the material here shown. If imperfectly purified before final distillation, it may destroy a batch of dye intermediates, and in this event, the tar distiller can but expect his material to fall into disrepute. The raw material of the tar distiller is highly heterogeneous and to obtain from it products of consistent quality, there must exist an outlet for the impurities. There are, indeed, certain fractions of coal tar marketed whose specifications are not so rigid as to prevent the admixture, within limits, of other tar products resulting from processes of purification. The tar distiller, however, uses whenever possible the less marketable materials as fuel under the stills or boilers.

The Sales Department of a chemical undertaking continue to urge their technical colleagues to produce—if possible without additional cost—an article, be it creosote, pitch, anthracene, sulphate of ammonia, etc., which shall, in competition with other similar products, establish its supremacy on the market by superiority in the particular quality for which it is required. Now it is useless to have attained superiority unless consistency of output may be maintained. A not unimportant duty of the chemist in the gas industry is to aid the gas engineer to produce from a heterogeneous material coal products—be they gas, coke, tar or ammoniacal liquor, of consistent quality. It is essential that the gas engineer give first attention to the main product, coal gas, and in this respect the author regrets that one of the clauses of the Parliamentary Bills which the gas industry joined in framing—namely, that relating to the limit imposed upon the variation of calorific value did not refer to variations above, as well as below the declared calorific value—was not contained in the final Acts.

The next most important product of the gas works from the point of view of revenue, is coke, and it is to this product that chemists must turn their attention. Its purity must of necessity be dependent upon that of the original coal. In addition to this adequate care is not

always given to the cooling process. The method of dry cooling with the exclusion of air as practised by several gas works is ideal and it is hoped that such a method may be found capable of general application. Notwithstanding this the coke of to-day is a high-class industrial fuel and will demand even a more ready market than at present, and will probably bring a greater revenue to the gas undertakings in the future, if its manufacture is perfected. More attention should be given to the advisability of selecting, screening or washing the coal prior to its carbonisation, for the purpose of reducing the ash and sulphur of the resulting coke. This is no reason why, for industrial purposes, coke should not in the future entirely replace raw coal, and it is believed that the cost of reducing the ash content of coal prior to its carbonisation would be repaid by the saving of labour costs for clinkering and the greater efficiency that may be obtained by the use in industry of coke so made. The opportunity may, however, be taken of describing to you a process recently worked out by E. R. Sutcliffe and Edgar C. Evans, whereby gas coal may yield a coke which is very suitable as an industrial fuel in that the ash from it falls away as a fine powder, completely free from combustible matter. [A sample of this ash, which is of a silky nature is shown.] In this process coal, admixed with a small quantity of breeze to prevent expansion during carbonisation, is ground to a fine state of division. It is then washed by a flotation process, dried and briquetted and subsequently carbonised. In the first place the briquettes are very dense and this, coupled with the reduction of ash, allows a greater throughput and larger output of gas and byeproducts from existing plant. The coke retains approximately the form of the original briquette. [A specimen was shown.] It is not friable and is conveniently transported. Many claims are put forward by the inventors regarding the increased yields of distillation products, but the process has not yet been sufficiently examined by the author to allow of a critical discussion.

It is perhaps more particularly the problem of coke as a domestic solid fuel that should receive our attention. In the first place, it is assumed that, however efficient the gas fire and gas heating appliances in the future may be, there will remain a wide market for a good solid fuel.

Even if there is a doubt among gas technologists upon this question, there must be unanimity in the belief that raw coal should not be burned for industrial or for domestic use. Above all, coal, which is the basic raw material representing this country's main wealth, should not be exported in its raw state, but should be first treated, preferably at our gas manufacturing centres, for the manufacture of gas, motor fuels and raw materials for the chemical industry. It is not proposed to advocate to you the practice of low temperature carbonisation. Not only is the financial balance sheet of low temperature carbonisation less satisfactory than that of the manufacture of straight coal gas as practised to-day, but the great increase in the quantity of coal which would have to be carbonized, the difference in the nature of the products—particularly of the gas and the tar—the simultaneous creation of a market for the solid fuel, in addition to the disabilities surrounding the balance sheet, are all factors which cause the gas engineer to appear to be lethargic in this matter. It is not difficult to analyse the attitude of mind of the organic chemist on this question, but it is one thing to appreciate the attitude of mind, and another to revolutionize a stable industry when the financial advantages are certainly not apparent. This attitude of mind may be best explained by stating that the gas industry is one with which the organic chemist cannot be expected to be in immediate sympathy as its basic process is one of destructive distillation. The industry is indeed a poor training ground for the organic chemist who, after a long training during which he learns to handle and conserve organic molecules during a reaction in the laboratory (which means obtaining a high yield of the required product) is naturally shocked at the ruthless destruction of the coal constituents during high temperature carbonisation. It does not, however, take long for this discouragement to disappear, for he is rapidly made aware of the fact that high temperature gas production is a financially sound proposition.

The carbonisation of coal at low temperature is not in itself unsound, and it will probably be practised more largely in the future. Aiming at treating raw coal prior to its use, it constitutes a decided step towards the abatement of smoke, and the waste of valuable constituents of coal at home and the

conservation of such constituents in this country, if the solid fuel resulting from this process is that eventually to be exported. Solely from the point of view of smoke abatement, any solid fuel which may be burned with the ease of coal, and with as little trouble, will have a very ready market.

Now, the bye-product coke oven industry has sprung up in this country, and it is a question whether at least the major operations of this industry should not have been situated at gas works, for it is proved that the gas manufactured is quite suitable for a town's supply of gas. It should be at least admitted that the gas industry might have taken a more integral part in the building of this coke oven industry. The question now arises, are we about to permit a domestic fuel industry to be created and constitute itself as another coal distilling undertaking, marketing in competition to the gas industry solid fuel which will not only affect the use of coke for domestic purposes, but may even influence the output of gas for heating purposes. This is the problem that the gas works chemist will be expected to solve, and it is probable that he has already proceeded a long way in the direction of its solution. In an adjacent room there burns a fire of smokeless fuel, which has been made with gas coke as the basis; briquetting has not been used, neither is pitch the binding material, for this latter is not suitable for the manufacture of a smokeless fuel. The binding material is produced by the admixture of a proportion of cheap coal. The whole is heated to the temperature of the waste gases in the retort house. The process is a rapid one, as there is not much volatile matter to be driven away, but that which *is* driven away is recovered and has a definite market value. The volatile content of the resulting fuel is from 6 to 8 per cent. [A sample of the fuel is here shown.] It is not friable and is readily transportable. It ignites as readily as coal, and it is thought that it would be a material superior to coal were it not for the original ash in the coal and coke from which it is manufactured. On account of this domestic fires from this smokeless fuel are dirtier as regards ash than similar fires burning good household coal. When this question of ash is overcome, either by selection, screening or washing, it is then, I think, that we can be assured of possessing a material that will even be preferred to coal, and gas undertakings will have made a further and, perhaps, a final contribution to the smoke abatement difficulty. The material burns to the silky-like ash described previously.

Much has already been written and said upon the advantages to be reaped by the abatement of smoke and it will be readily understood that gas undertakings will be one of the first to find immense advantage by the absence of solid particles in the air. The heritage that we possess in the gas industry by virtue not only of the efficiency of the gas making process, but also of the efficiency and economy of gas appliances, is one that is generally appreciated. The advantages of gas for heating and for power purposes are admitted by all who have adopted it. It is, however, in the production of light by the incandescent mantle that we are particularly fortunate. There exists in my opinion, no other means of artificial light which produces, on the one hand a soft light which is particularly suitable for the avoidance of eyestrain, and on the other a healthy circulation of air within the building or living room, and finally a degree of warmth which is an asset in all cases in eight months out of the twelve of each year, but which constitutes a very real convenience in the height of winter. Gas lighting is generally credited with the objection that our ceilings become blackened by it and more frequently require whitewashing. This is due to the fact that air, laden with solids, is driven at a high velocity in an upward direction by the ventilating effect of the burner, and then by the sudden reduction of this speed by contact with the ceiling a portion of the solid material is precipitated upon the ceiling. It is still believed by some that unburnt particles of carbon from the gas exist amongst the *mélange*, but this is untrue. With other forms of lighting there is no less solid matter in the air but without this ventilating effect such solid matter may find its way to the lungs of the occupant of the room. It is here possible to show slides which have been kindly loaned for this lecture by Dr. C. W. Saleeby, and demonstrate the lung of a town in contrast to that of a country dweller. (Figs. 5 and 6). Now it is a simple matter, and costs little, to cause our ceilings to be whitewashed but it is a task beyond even the manipulation of the surgeon of to-day to whitewash our lungs. Now there is a natural tendency in the human being to be more conscious

FIG 5.—Section of Miner's Lung.

FIG. 6

Sections of Lungs

Miner. Town-Dweller Shepherd

of the hole in the back of the sock above the shoe line than of one in the toe, and it must be admitted that, unlike the ceilings, our lungs are not open to the inspection of our friends and critics. There will come a time when it is considered as important to have a clean set of lungs as it is to-day to possess a set of sound and clean teeth. The gas engineer must realise that with a smokeless atmosphere gas lighting, secure though it is to-day, will have its one supposed disability removed.

In conclusion, my thanks are tendered to Dr. Charles Carpenter, whose ideas form the basis of our experimental work and whose guidance is essential to any success that may have been attained. I should also like to take the opportunity of acknowledging my indebtedness to my assistants (Messrs. H. Hollings, M.Sc., H. Pickard, B Sc , and H. Stanier, B.A.), and to the demonstrator of this evening, Mr. C. E. Carey, B.Sc.

[Figs 5 and 6 are reproduced by courtesy of the Editor of the *Gas Journal*.]

DISCUSSION.

THE CHAIRMAN (Mr. W. J U. Woolcock, C.B.E , M.P.), in opening the discussion, said he was sure everyone present would agree that

the paper had been a most interesting one and had dealt with a great many different subjects. He thought he detected, underlying the artistry of the method of the author in presenting the paper, a certain amount of possibly contentious matter. His own reading had been more wide than thorough, but he certainly thought that at certain times he had come across differences of opinion on such subjects as carbon monoxide and smokeless fuel.

Dr J. S. Haldane, F.R.S., said he had listened with delight to the paper, which was full of interest from beginning to end, and he congratulated the Society on having obtained the services of the author to read such an interesting paper As the Chairman had said, there were a great many controversial points dealt with by the author. Personally he proposed to deal with the last question discussed in the paper namely, the question of lungs. The author had painted a rather gruesome picture of the lungs of a town dweller and the lungs of a miner, and he wished to present the other side of the picture. He was pretty well acquainted with the subject, as he had had a great deal to do with it in one way or another for a very long time The people in this country who breathed most coal dust were undoubtedly coal miners, but if the statistics of the deaths of coal miners from lung disease, particularly from consumption, were studied it would be found that such men were extraordinarily healthy. Among coal miners the death rate from consumption, which was commonly attributed to dust, was lower than it was amongst farm workers. That did not bear out the bad reputation which the inhalation of smoke particles had in popular opinion. He was not arguing that people should live in a smoky atmosphere: he was entirely in favour of having the air of London clear of smoke, first because the smoke made everything dirty and consequently made it more expensive to live in London and, secondly, because smoke obstructed the light and in that way caused much trouble, but he was very doubtful as to the effect the mere breathing of smoke particles had on the health of a man When smoke particles went down into the lungs they were taken up by microscopical cells, and those living protoplasmic cells had the duty of cleaning up dust. They could be seen under the microscope crammed full of dust particles After collecting those dust particles, they wandered up the air passages and came out. They were constantly carrying on that work of cleaning, and a person who lived in a pretty dusty atmosphere seemed to acquire a very efficient cleaning service on the part of those cells. During the time that a coal miner was working in the mine he always had what was known as a "black spit," which lasted for a considerable time after he had come out of the mine; it went on for weeks. That was good evidence that the cleaning service of the man's lungs was doing its work well. The same cells had the duty of cleaning up micro-organisms, such as tubercle bacilli, which got into the lungs, and perhaps that was the reason why coal miners were so extraordinarily free from consumption. Fifty years ago the death rate amongst miners was very high, but there was very little phthisis. On the other hand, there were some kinds of dust that were deadly, one of those being quartz dust. For some reason or other, the cells of which he had been speaking were not capable of dealing with pure quartz dust Many of the gold miners in the Transvaal contracted phthisis and died of it, and one of the most dangerous industries in this country, as Dr Collis had shown, was a very ancient one, i e., the chipping of flints. Flint was a pure quartz and a small amount of flint dust which was breathed by the few men who still made flints caused them to be very subject to phthisis The reason apparently was that the lungs were not accustomed to deal with out of the way chemicals like pure quartz dust; the quartz was totally insoluble and of no interest to the cleaning cells, so to speak. Ordinary wholesome dust was mixed with all kinds of things. Ordinary dust, for instance, made from earth was full of organic matter, which was just what the cells liked to to have; they immediately took up that dust and walked out with it.

Prof. C. V. Boys, F.R.S., said he agreed with Dr. Haldane that the paper had been a most interesting one, and it was quite obvious that everyone present was delighted with the very happy way in which the author had dealt with a number of subjects. He proposed to say a few words on the same question as Dr. Haldane had spoken upon and also to refer briefly to the subject of smokeless fuel. He had had something to do with the Minerals Separation Co. and their processes, which depended upon surface tension and not upon a mere washing operation. By this means certain minerals could be separated from others as froth, as was well known in the case of sulphide ores. They were now treating powdered coal to remove ash, *i.e*, such ash as is in the form of separate particles, not that inherent in the coal itself, and thus produce a material for briquettes containing less ash then the coal itself. In the same way where there was waste material containing coal dust they could separate the coal from the dirt and produce good coal for briquettes containing less ash than the primitive coal. He had recently burned some of these successfully. Some month ago he sent a short communication to the "Journal of Gas Lighting," which had been treating as a problem the use of common gas coke as a domestic fuel, in order to show that there was no problem. He always burned coke in his own house and would not have coal for the living rooms. He

did not have any special appliances for burning the coke, but merely used an ordinary well fire with the iron grid removed and the ash pit filled with common brickbats; if there were any secret in the burning of coke in a domestic fire it was to have no iron, iron being poison to a coke fire, and to have no draught. The violent draught needed in a small coke fire burning in an iron surround was not required if the coke was put in a heap on a brick ground with a firebrick back, in which case no air could get to the coke except that which came in at the front and went out at the top. A small coke fire with its small natural draught would keep alight an incredibly long time, producing a dull red heat which would throw a gentle heat into the room; if a larger fire were made it would induce a stronger draught and the stronger draught would in turn make the fire hotter. A coke fire became red hot and gave a proper heat into the room in less time than a coal fire, because there was no distillation process going on first. All that had to be done to such a fire to keep it in order was to put a poker underneath it two or three times a day just to lift it up so that the ash could filter through and fall to the bottom. All the coke dust and small was simply put carefully on the top of the fire when the fire was burning well and it remained there and burned away, so that there was no waste.

Mr. Charles Carpenter, D.Sc., said he had very much enjoyed listening to the paper and wished to join with the other speakers in congratulating the author upon its delivery. With regard to the advantages of gas lighting, to which the author had referred, a new school was arising to-day which seemed to think that gas lighting was a thing of the past. He thought it was the greatest possible mistake to tell people that and to advise them to have their houses lighted by electricity. It was true that during the war there were certain irregularities in the composition of gas which made its use, not only for lighting but also for heating purposes, not altogether free from inconvenience, but that was a state of affairs for which there was no justification at the present time. There was no reason why gas should not be used now for lighting with the same certainty of obtaining definite results, the same simplicity, and the same absence of care and attention, as obtained in the case of electric lighting. In order that that should be so it was important that attention should be paid to another matter to which the author had referred. The author had quite properly drawn upon his German experience for an example and had shown that it was most essential that if a definite quantity of a dye was taken it should under all circumstances give a definite result. If the normal 99 or even 100 per cent. product was distributed there might be occasions when the quality would fall slightly below and the result would be extremely detrimental to the dyers' work, but by the system to which the author had referred of lowering, as it were, the product to a definite percentage it was possible—and the process was carried out on a large scale—to obtain absolutely definite results from the product which the German dye producer put on the market. That method was exactly the one which should be encouraged by the gas engineer in the matter of the composition of his gas, and it was one respect in which the chemist could be of enormous use to the gas engineer in his operations. He thought that in the past the gas engineer had thought far too much of volume. Thanks to the proposals of Sir George Beilby and the Fuel Research Board, that had now been altered and gas engineers now talked of therms instead of cubic feet. He would suggest that young engineers should train themselves up in that method of expression and should impress upon those who still practised the old method the importance of speaking in the language of exactness.

Professor H. E. Armstrong, F.R.S., said that he could best express his feelings in the words of a great Victorian poet: "Come to my arms, my beamish boy," and chortle in his joy. He had waited years for that evening. Mr. Evans had termed himself a gas-chemist. He (the speaker) objected to any qualification of the term "chemist"; a man was or was not a chemist; but whatever he might be as chemist, Mr. Evans was an artist and a poet. He had given them a variety entertainment that could not conceivably have been set before gas-men ten years ago, when he, and perhaps one or two more, were the only chemists attached to gas companies. The use of the chemist, in fact, only dawned upon the industry after the outbreak of the late war; now, at last, he was regarded as indispensable to its success.

He could not let the opportunity pass of paying tribute to the extraordinary service Dr. Carpenter had rendered, by his efforts, to put the industry upon a scientific basis, to standardise gas and to supply honest goods; there was very great danger, however, that his example might not permeate through the mass. Though Mr. Evans had not attempted to paint the town red, it seemed he had tried to stain gas blue. Blue, perhaps, was a little symbolic of the gas works; they spoke of blue-water-gas, and he was inclined to think that they were in a "blue funk" as to their future, the state of the industry being now a serious one. Reference had been made to the subject of carbonic oxide. He thought a great debt of gratitude was owing to Dr. Bone for having raised the question. In a very short time Dr. Bone had done that which chemists had unsuccessfully long striven to do—he had taught the public that there were two oxides of carbon and he had taught people to know the names of both, to distinguish between them and to realise that one was com-

bustible and the other incombustible A good deal had been said about gas being poisonous. It was, but mainly to such as put their heads into a gas stove for suicidal purposes It had been his privilege to be invited by the author to visit the laboratory of the South Metropolitan Gas Works to witness the smoking experiments to which the author had referred and he had been surprised at the results, which were very startling It was found, taking an ordinary cigar, that only about one-third excess air passed through it, so good an instrument as a stove was a cigar. He took it that few stoves had that efficiency; most of them passed a good deal more waste air There was a ratio of carbon dioxide to carbon monoxide of only two to one, so perfect was the reduction In one analysis that he carried out there was 6 per cent. of carbonic oxide, and the better cigars gave more. If one thought what the atmosphere of a first class railway carriage with half a dozen people smoking in it must be like, it would be realised that, if carbon monoxide were dangerous, the small amount met with under ordinary circumstances was not likely to be harmful A distinguished physiologist told him a few weeks ago that he could always detect carbonic oxide in his blood. With regard to sulphuretted hydrogen, he did not think it was necessary to pay such special attention to that, but the sulphur that was left in other forms was a very serious matter, and did far more harm than carbonic oxide His own house was on the South Metropolitan supply, and, small as was the amount of sulphur in that company's gas, objects which had been exposed to the gas showed most serious deterioration under the influence of sulphur Dr Carpenter had been endeavouring to get rid of the sulphur and had done a great deal in that direction He understood the work was being carried on at the present time and that improvements were likely to take place, and he looked to Dr. Carpenter to remove the last disability from gas If gas could be obtained free from sulphur there would be very little to be said against it At a meeting of the South Metropolitan Gas Company held that day he said in the course of his speech that Dr Bone had at the back of his head something far more important than the poisonous effects of carbonic oxide, i.e., the thermal value of the gas There was an attempt being made throughout the country at the present time to persuade people into the view that a low thermal value was preferable, but he was sure that was not the case. What was really wanted was a gas of as high a thermal value as possible if gas appliances were going to be improved and made more suited for use in the future. There had been a good deal of discussion recently on the subject of the feeding of schoolboys, and one point that should be realised in that connection was that food nowadays was not nearly so good as it used to be because of the way in which it was cooked. The open range had been given up and people had taken to the gas stove, with the result that there had been a very serious deterioration in the value of food. That was only gradually being appreciated. If a gas cooker could be made on the lines of the open range of the past, an immense gain would result. The wonderful burner produced by Dr. Bone some years ago was of that order; there was a blazing surface which was superior to that of the old fashioned stove and nothing could be more perfect for use in grilling and roasting, but unfortunately the flame lit back. The hope of obtaining improved gas burners lay in the direction of getting improved gas. With regard to smokeless fuel, the author had been pleading in favour of a fuel made by using up the coke that the gas industry produced. Everybody, however, was not going to burn coke in the clever way Prof. Boys burned it After all, the amount of coal used by the gas companies was only about 10 per cent. of the total amount used, so that it did not very much matter what they did with their coal The rest of our coal was not going to be treated in the way that the gas companies treated their coal, and it would therefore have to be distilled in a way that would enable as much oil as possible to be obtained from it The low temperature oils obtained could be used as fuel oils straight away, and other uses might be discovered for them. When coal was thus distilled, after it had been treated in the way Prof Boys had indicated, a fuel was obtained which would burn with extraordinary ease and with a minimum of ash If the small coal to which Prof Boys had referred was stored for any length of time it deteriorated and became oxidised and very little oil could be obtained from it, but if it was carbonised at a low temperature a material was obtained which would keep apparently for any length of time. It had not been under observation for very long, but during the ten years that it had been kept it had not changed in the very slightest degree. By low temperature carbonisation the coal would be stabilised and small coal could be converted into a solid material comparable with the largest and best coal and at the same time a gas would be produced of the quality which Dr. Carpenter was bent on giving to the public His own view was that, whatever the gas industry might choose to do now, in the long run they would be forced to become makers of low temperature smokeless fuel and obtain gas in so doing, the gas being a by-product, and they would supply the public with fuel The one curious result of that would probably be that the dye-stuff industry would disappear, unless the materials required could be made in other ways than from coal tar. There were other sources of some of them in sight, as for instance, the petroleum oils In conclusion, he wished to say that the paper had been of extraordinary interest and value, charmingly

delivered, and one displaying an unusual amount of imagination.

MR. F. GLOVER said those present were indebted to the author for a very interesting paper which drew attention to some very important facts connected with our national life. Very novel methods for avoiding the smoke nuisance were sometimes put forward, but it was often forgotten that the gas industry was already contributing in an enormous degree to the reduction of town smoke. The gas industry produced in the solid form something like 8,000,000 tons of coke and for the most part that coke was used in this country and must be contributing substantially to the reduction of smoke, because if those 8,000,000 tons of coke were not there 8,000,000 tons of coal would have to be used instead, and those 8,000,000 tons of coal would produce a very considerable quantity of smoke, besides a very considerable quantity of sulphur, which would be turned into the atmosphere and converted into sulphuric acid. The gas industry were doing a very important work in extracting the sulphur and making it into sulphuric acid in sulphuric acid chambers and using it in the industry. It was also forgotten sometimes that of the 20,000,000 tons of coal carbonised in gas works something like 10,000,000 tons was required for fuel purposes, and in that way the gas industry made another contribution to the smokelessness of towns. Coke was a very valuable smokeless fuel but the precision of the chemist was needed to remind those who sold coke that they ought to sell coke and not coke and water. More care should be taken in the choice of coal for gas making if there was to be a good finished product in the form of coke The ash originally contained in the coal was concentrated in the coke, and therefore weight for weight more ash was obtained from coke than from coal, whichever way the coal was carbonised, and to remove the excess impurities from gas coal was a very important function of the colliery owner. That had not been sufficiently realised in some coalfields, and the coalfields from which the London gas companies drew their supplies were the worst sinners in that respect. The Yorkshire colliery owners had put down modern coal cleaning plants and had reduced the ash in the coal very considerably, to the great benefit of the coke. It was no use making good coke fairly free from ash if it was treated as a residual. He did not like the word "residual"—it ought to be "by-product"—but the coke was too often treated as a residual; it was taken from the retort house and dumped in a heap where the rain could fall upon it. It absorbed a great quantity of water and was sold to the customer with varying quantities of water in it; the buyer had to drive that water off by the heat of his fire, a great many heat units being thus lost in the form of latent heat in the steam. The chemist should impress upon the gas engineer that it would be very much better if he took more care in producing smokeless fuel, to store it under cover and to fit it for the consumer, so that the greatest possible number of thermal units might be obtained from it when it was burned. The coke produced from the latest form of retorts, the vertical retorts, was made absolutely dry and ignited much more readily and burned much more cheerfully than other coke, that being the case particularly when continuous vertical retorts were used The coke produced in the future would therefore be much more satisfactory, and the difference had already been noticed in those towns where that new method of carbonising coal had been adopted. He was very glad to hear from the author that the South Metropolitan Gas Company had overcome the "naphthalene bogey" and it was very gratifying to find that the oil washing process which had been advocated for so many years was very effective when used in a proper and thorough manner, as was done under Mr. Evans' control

MR T HARDIE (President of the Institution of Gas Engineers) said it was very satisfactory to hear from the author that he had been able to reduce the naphthalene stoppages to such an enormous extent. With regard to carbon monoxide, it was well known to those who produced gas that for the last eight years there had been as much carbon monoxide in it as there was at the present time Turning to the subject of low temperature carbonisation, he did not think gas engineers would ever agree to become primarily oil producers. They were out to make gas and it was their intention to make gas, and, although in producing gas they might produce other things as well, they would continue to be first and foremost gas engineers

MR. DAVID BROWNLIE said with regard to the question of low temperature carbonisation *versus* high temperature carbonisation, the author was in favour of the latter, but personally he thought that was wrong. If the history of the gas industry from the time when it started, about the year 1795, was studied, it would be found that the temperature had been gradually increased in order to try to obtain more gas, making it weaker and weaker. He could remember the time when gas would actually light and give a candle power, but to-day nobody would accuse gas of giving any candle power! He took it the ideal of the gas industry was to have total gasification, to make one ton of coal give 50,000 ft. of gas with 30 per cent. of carbon monoxide. In his opinion the right method to adopt was not to try to take the 30 per cent. of volatile matter in the coal and convert it into gas, but the right method was the low temperature method of converting that 30 per cent. of volatile matter into no gas at all but all into oils and fuels.

MR. E. V. EVANS, in replying to the discussion, said that with reference to Dr. Haldane's remarks he did not suggest that the miner had a shorter life than other people. His point was rather that the lungs did become in the condition he had described, and he would like to ask those present, bearing in mind what Dr. Haldane had said on the subject, which they would rather have — clean lungs or "black spit," as Dr. Haldane called it. Prof. Boys' remarks on the flotation process were of considerable interest; the sample of fuel which had been burned on the premises had been treated by that flotation process and it had certainly shown itself to be an admirable fuel. As to Prof. Armstrong, he was, in Mr. Evans's opinion, the greatest living chemist. They had often talked together about low-temperature carbonization. This process was certainly an interesting one; and the fuel made was a fine material for the domestic hearth. These conversations with Prof. Armstrong and the results of his examination of low-temperature fuel, had caused him not only to advise the gas industry to beware of competition in the future from this material, but had stimulated him to work out the manufacture, as a gasworks by-product, of a domestic smokeless fuel He believed he had been misunderstood by Mr. Glover, because he was assuming that in the future the domestic raw coal at present delivered to a town should first be dealt with at the gas undertaking, which would then deal with a larger quantity of coal, obtaining cheaply a greater output of gas He suggested that the gas industry could deal not only with the industries it was dealing with now, but also with the domestic fuel industry; for he felt certain that a time would come when a low-temperature carbonizing industry would come about if the gas industry did not take the steps to secure it

On the motion of THE CHAIRMAN, a hearty vote of thanks was accorded to Mr. Evans for his interesting paper and demonstrations, and the meeting then terminated.

GENERAL NOTES.

NON-FERROUS METALS RESEARCH.—The second annual meeting of the British Non-Ferrous Metals Research Association was held at Birmingham, on March 2nd Mr. T. Bolton, who presided, comprehensively surveyed the activities and progress of the Association which has now over 100 member firms. A number of important investigations are being conducted by the Association in various laboratories. He emphasised the fact that division of labour is as important among brain workers as among hand workers and co-operative research is the best and most economical method. He referred particularly to the proposal of the Association to establish University Fellowships for post-graduate research. One of the speakers was Sir Frank Heath, Secretary to the Department of Scientific and Industrial Research, who gave several illustrations to show the value of co-operation between user and producer. He thought the provision of an intelligence service was one of the most valuable things an Association could do. He was also, he said, particularly interested in the projected establishment of research studentships and he offered the assistance of his Department in working out a scheme. The growing appreciation of the value of research was, he added, indicated by the absence of any reference to his Department in the proposals made by the Geddes Committee.

THE THEORY AND PRACTICE OF ACID MIXING.—A special series of reports is being published for the Department of Scientific and Industrial Research in order to make available, for the benefit of the industries concerned, results of scientific and industrial value contained in the technical records of the Department of Explosives Supply of the Ministry of Munitions. The work recorded was done at or in connection with some of the National Factories during the War. The preparation of the necessary abstracts of information was begun by the Ministry of Munitions at the close of the War, and arrangements were afterwards made by the Department of Scientific and Industrial Research to complete them. Copies of these reports may be obtained from H.M Stationery Office The fourth and latest report, "The Theory and Practice of Acid Mixing," is dealt with under the following sections:—Section 1 Acid Cycles, Acid Balances and Control of Plant Output Section 2. The Position of the Acid Mixing Plant in the Acids Cycle and the Procedure adopted in Mixing. Section 3 Plant and Process for Acid Mixing

INDIAN PEARLS AND "CULTURED" PEARLS.—In view of statements to the effect that Japanese "Cultured" Pearls are indistinguishable from, and equal in value to, Indian pearls, and in order to re-assure possessors of pearls, a number of firms on their own behalf announce that the value of Indian pearls is not affected by the introduction of 'cultured" pearls, the reasons given being:—(1) "Cultured" pearls are beads covered with pearl nacre of varying degrees of thickness. (2) They can only attain a comparatively small size, and on account of their quality do not compete with Indian pearls, from which they can be distinguished. (3) They cannot be compared with pearls, any more than rolled gold with solid gold, or electro plate with silver. The French Chambre Syndicale have forbidden their entry or sale in Paris as pearls.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, MARCH 13 . People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Frederick Mott, "Mind and Body"
University of London, King's College, Strand, W.C., 5 p.m. Rev Prof S. W. Green, "Idolatry"
Electrical Engineers, Institution of (North Eastern Centre), Armstrong College, Newcastle, 7.15 p.m. (Dundee Sub-Centre), University College, Dundee, 7.30 p.m. (1) Mr J Anderson, "Electric Motor Starters." (2) Mr. L H. A Carr, "Induction Type Synchronous Motors"
Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S W 5.30 p.m. Mr. T. R Johnson, "Railway Problems in China and Australia."
Geographical Society, Kensington Gore, S W. 5 p m

TUESDAY, MARCH 14. . Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C , 5 30 p m Annual General Meeting
Rubber Industry, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C , 7.30 p.m.
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C , 8 30 p m. Lieut.-Col L. S. Amery, "Migration within the Empire"
British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E C , 7 30 p.m. Mr P A. Wells, "Painted Furniture, Old and New"
Textile Institute, 16, St. Mary's Parsonage, Manchester. Mr W Harrison, "The Human Element in Industry"
Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p m Mr. J P. Mills, "The Lhota Nagas."
Photographic Society, 35, Russell Square, W C., 7 p.m Annual General Meeting.
Metals, Institute of (Local Section), at the Chamber of Commerce, New Street, Birmingham, 7 30 p.m Mr D. H. Ingall, "The Mechanical Properties of Pure Rolled Zinc" (Scottish Local Section), 39, Elmbank Crescent, Glasgow, 7.30 p m (1) Annual General Meeting. (2) Dr R S Hutton, "Motion Study and its Application to Training (with particular reference to Metal Polishing)"
Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W , 4 30 p m Prof A J Toynbee, "The Break-Down of the Eastern Frontier of the Roman Empire in the Seventh Century, A D its Antecedents and Parallels."
Royal Institution, Albemarle Street, W., 3 p m Sir Arthur Keith, "The Anthropology of the British Empire" (Lecture IV.)
University of London, at the Royal School of Mines, Imperial College, South Kensington, 5 30 p m Colonel N T Belaiew, "The Crystallisation of Metals." (Lecture IV.)
Anglo-French Society, Scala House, Tottenham Street, W , 6.15 p.m M M Thiery, "Le Vaudeville"
Electrical Engineers, Institution of (North Midland Centre), Hotel Metropole, King Street, Leeds, 7 p m (Scottish Centre), North British Station Hotel, Edinburgh, 7 p m. Mr. E S. Bing, "Telephone Line Work in the United States"
Asiatic Society, 74, Grosvenor Street, W , 4 30 p.m Mr L Shuttleworth, "Some Peoples and Religions of the Punjab Himalayas"

WEDNESDAY, MARCH 15. . Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Mr W. H. Dickinson, "The Organisation and Conduct of Tuberculosis Dispensary Work."
Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p m. Mr. W. Piercey "Psychology in Industry."
Microscopical Society, 20, Hanover Square, W., 8 p.m. Mr J. E. Barnard, "The Future of the Microscope in Medical Research."
Meteorological Society, 49, Cromwell Road, S.W., 7.30 p.m.
Electrical Engineers, Institution of (South Midland Centre), The University, Birmingham, 7 p.m. Mr. J. Anderson, "Electric Motor Starters." (Sheffield Sub-Centre), Royal Victoria Hotel, Sheffield, 7.30 p.m. Mr. F. Langley, "Notes on the Practical Operation of E.H.T. Protective Gear."

THURSDAY, MARCH 16. . Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Dr. V. E. Pullin, "Radiological Inspection Work."
University of London, King's College, Strand, W C., 5.15 p.m. Prof. Nils Bohr, "The Quantum Theory of Radiation and the Constitution of the Atom" (Lecture II.) At the London School of Medicine for Women, Hunter Street, W.C., 5 p.m. Dr. H. H. Dale, "Some Recent Developments in Pharmacology." (Lecture IV.)
Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W , 5 30 p m, Annual General Meeting.
Royal Society, Burlington House, Piccadilly, W., 4 p m.
Antiquaries, Society of, Burlington House, Piccadilly, W , 8 30 p.m.
Oriental Studies, School of, Finsbury Circus, E C , 5 p m. Dr. L. D. Barnett, "The Hindu Culture of India." (Lecture III.)
Chromatics, International College of, Caxton Hall, Westminster, S.W., 8 p m Mr A. D. Stocker, "Life and Colour, from the point of view of Therapeutics."
Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M Emile Cammaerts, "La Poésie Moderne de la Langue Francaise." (Lecture II)
Royal Institution, Albemarle Street, W., 3 p.m. Dr P Chalmers Mitchell, "The Cinema as a Zoological Method" (Lecture I)
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W C , 6 p m. Mr. J G Hill, "Phantom Telephone Circuits and Combined Telegraph and Telephone Circuits worked by Audio Frequencies."
Transport, Institute of, Preston Mr. T. W. Royle, "The Importance of Detail and its Place in an Efficient Railway Organisation"
Dyers and Colourists, Society of (West Riding Section), Leeds Messrs. L. G. Radcliffe and H G Shatwell, "A Synthesis of Glycerine and a Novel Chemical Reaction."
Chemical Society, Burlington House, Piccadilly, W , 8 p.m. (1) Mr H. B. Baker, "Change of Properties of Substances on Drying." (2) Messrs H. Burton and J Kenner, "The Influence of Nitro-Groups on the Reactivity of Substituents in the Benzene Nucleus." (Part VI) "The Elimination of Halogen during the Reduction of Halogenated Nitro-Compounds."

FRIDAY, MARCH 17. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p m. Mr. F. Pick, "The Operation of an Omnibus Company, with reference to Capacity and Cost under given Conditions."
University of London, King's College, Strand, W C , 5 p m. Prof. R Robinson, "Orientation and Conjugation in Organic Chemistry from the Standpoint of the Theories of Partial Valency and of Latent Polarity of Atoms" (Lecture III)
Royal Institution, Albemarle Street, W., 9 p.m. Principal A P. Laurie, "The Pigments and Mediums of the Old Masters"
Metals, Institute of (Local Section), The University, Sheffield, 7.30 p.m. Mr. W. R. Barclay, "Some Nickel Alloys."
Japan Society, 20, Hanover Square, W , 5 p m. Rev W Weston, "Some Aspects of Rural Japan."
Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m
Dyers and Colourists, Society of (Manchester Section). (1) Prof. A. J. Turner, "The Influence of Humidity on Textiles." (2) Mr. W. H H. Norris, "Detection and Prevention of Loss of Material in Dye and Chemical Works."
Chemical Industry, Society of (Local Section), The University, Liverpool, 6 p.m. Dr. W. E. Gibbs, "The Industrial Treatment of Fumes and Dusty Gases."
Electrical Engineers, Institution of (Students' Section), Savoy Place, Victoria Embankment, W.C., 7 p.m. Mr. C. C. H. Wade, "The Electron Theory."

SATURDAY, MARCH 18. . Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Radioactivity." (Lecture III.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office, not later than the Monday morning of the week preceding the Meeting.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 20th, at 8 p.m. (Cantor Lecture.) GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constituents of Essential Oils." (Lecture 1.)

WEDNESDAY, MARCH 22nd, at 8 p.m. (Ordinary Meeting.) A. P. LAURIE, M.A., D.Sc., F.R.S.E., H.R.S.A., Professor of Chemistry to the Royal Academy of Arts, "The late Mr. Holman Hunt's Experiments on the Permanency of Artists' Oil Colours." Sir ASTON WEBB, K.C.V.O., C.B., P.R.A., in the Chair.

FRIDAY, MARCH 24th, at 4.30 p.m. (Indian Section.) Professor HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India." Sir THOMAS HENRY HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 8th, 1922; MR. JOHN MURRAY, M.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Anderson, Alexander James, C.S.I., Haslemere, Surrey, and Rangoon, Burma.
East, Alan Neville, A.M.I.E.E., A.M.I.Mech.E., London.
Lloyd, Albert Lawrance, London.
MacIsaac, Donald Francis, B.A.Sc., Sydney, Nova Scotia.
Phillips, Frederick, B.Litt., Deganwy, N. Wales.
Sanders, Gerald Worsdall, Apperley Bridge, Bradford.

The following candidates were balloted for and duly elected Fellows of the Society:—

Basu, M. N., Calcutta, India.
Hayes, Sidney George, Ilford, Essex.
Orton, Charles James Swaffield, Broadstairs.
Rajhavan, S. Srinivasa, B.A., B.L., Madras, India.

A paper on "The Proper Functions of Trade Unions" was read by Mr. W. A. APPLETON, C.B.E., Secretary to the General Federation of Trade Unions.

The paper and discussion will be published in a subsequent number of the *Journal.*

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1921 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 25th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce."

The list of those who have received the medal since its institution in 1864 was printed in the last number of the *Journal.*

PROCEEDINGS OF THE SOCIETY

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 15TH, 1922.

SIR HENRY NEWBOLT, C.H., D.Litt., LL.D., Chairman of the Departmental Committee on the Teaching of English, in the Chair.

The paper read was :—

THE NEED OF SPEECH TRAINING AND THE NECESSITY FOR A NATIONAL CONSERVATOIRE.

By CLOUDESLEY BRERETON.

The other day I heard of a theatrical manager who engaged for the leading lady in a new play a totally untried tyro, simply because she "looked" the part he was wanting to fill. All she had got to do, so he told her, was to be "natural."

Now many people may, more or less, look the part till they open their mouths. They look indeed like an angel, but talk like poor Poll, to quote the well-known epigram on Goldsmith. Maître Corbeau doubtless appeared a kind of super-blackbird, not only to himself, but to many others, till the fox induced him to give a specimen of his singing qualities. Moreover, different circumstances demand different types of naturalness. What may pass for good form at the Ritz would be out of place in Westminster Abbey. The actor is a chameleon, who takes his colour and his cue from his surroundings. His role is not so much to be natural as to appear so. That is the real "paradoxe du comédien." Nor is it merely a question of looks, but of speech. A person who talks naturally in a drawing room will very probably be inaudible on a big stage, especially in this country, where it is unfortunately *natural* for the great majority of persons to be inaudible at a comparatively short range. Of course, there are a few long range speakers like the late Mr. Gladstone, who used to address Queen Victoria as if she were a public meeting, but it seemed the reverse of natural to Her Majesty. Even if a person has a natural singing voice, it is now universally agreed that she cannot sing in grand opera without a long and elaborate training. Yet it is still widely denied that training, even for the actor, is necessary in the sister art of Diction. That, however, was not the belief amongst the ancient Greeks and Romans, nor is it either the belief among their modern representatives—the French.

This theory of being "natural" is part of the ultra-individualism of the day. Germany was full of this *temperamentvoll* doctrine before the war. "Be yourself" seems so much easier than the older doctrine "know yourself." Hence its wide popularity to-day, though as a theory and a catchword it has existed with very varying meanings for centuries. The Stoics made it the master-key of their doctrine. Live naturally, they said. Rousseau was all for a return to Nature. The comment in each case is "Yes," but what kind of nature? Stated in this skeleton form, the doctrine is so general that it means nothing in particular, or else implies everything. It is no doubt true as far as it goes, but it is about as helpful as saying that the whole of medicine is summed up in the phrase "keep well." That brings us "no forader," and renders hospital clinics and the *materia medica* every whit as indispensable.

The cult of uncultured nature in the XXth century is nearly as great a myth as the cult of the uncultured savage in the XVIIth. It derives no little force from the general revolt against authority, which, in the realm of art, takes the form of a revolt against technique itself, and as such is mainly due to a misapprehension of technique itself and its functions. What, then, is technique?

It is nothing more or less than the *generalised* experience of the art or craft concerned, be it painting or sculpture, diction or dancing. It is not a substitute for, but ancillary to creative work. Those who are misled into believing the former, acquire the whole world of technique and lose their own soul. That is the tragedy of many a *prix de Rome*. But its presence in any really creative work only adds greater richness and ripeness to it. Education, whether on Montessori or other lines, has for one of its chief aims and objects the imparting of technique, or a knowledge of the tools of learning and expertness in using them. Technique from this aspect is the self-imposed yoke whose service is perfect freedom, for without it freedom is mere licence. Or, in other words, the greatest artist consciously submits to technique in order to triumph over it, being ever ready to break any one of its rules in order to achieve greatness, but not to break them all at once, for that were mere anarchism — ready again, when he had broken them, to explain why he did so. Every supremely great artist is a potential Antigone whose breach of the highest conventions is justified by the results, and all the more readily explainable by the artist himself, the more profoundly he is acquainted with the existing canon of conventions, which like a Judge of the Supreme Court he is perpetually *interpreting*, and re-stating. The greatest artists, the Leonardos and the Phidiases are those who have pondered the deepest on their art and turned the searchlight of their consciousness on the productions of their subliminal selves.

Of course, without inspiration there can be no true art. But *vis consili expers mole ruit sua,* and inspiration even in its happiest and apparently most spontaneous moments

depends on calling into play that previous experience of a life-time external or internal of which Whistler spoke. If the painter or poet is to utter adequately the thoughts that arise in him, among the forces he mobilises for self-expression for creating the outward and visible symbols of his passion, are just those technical experiences he has been amassing consciously or unconsciously during the preceding part of his life.

This is the true element in the saying that genius is infinite capacity for taking pains. Genius always does take infinite pains, though the result may only be ultimately revealed by the shortening of the artist's life. Qualitatively a genius may live 10 years in 10 days, and die at 30. But whether those pains be the work of the brooding spirit within or the birth-pangs of self-expression, in either case or both, they may be lightened and alleviated by studying the generalised experience of the particular art or craft concerned, always bearing in mind that one cannot get hold of too much of this experience if one looks at it not as a set of immutable laws, but as so many starting points for further discovery, truths up to date and nothing more, though some of them may remain unaltered for centuries, like the law of gravity, till an Einstein comes along.

If technique then is essential in all the arts, what is its role in speech training? Surely here as elsewhere it has for its function the handing over of the acquired lore of the elocutionary craft, which, while it differs in its applications according as it deals with pulpit eloquence, public-speaking, platform recitation, dramatic work or the mere speech of the average school-boy, can none the less roughly be sub-summed under the four headings of gesture, pronunciation, intonation (including pitch and stress) and rhythm. These form, so to say, the four chief divisions of the grammar of the subject —its quadrivium, in fact.

I. Gesture is really the rudimentary and primitive language of mankind. Whether the acquisition of language be more difficult for English people or not may be a moot point, but certainly the language of gesture is more difficult for them to acquire than for other folk. Not infrequently the gestures of an English speaker are not only inexpressive and incongruous, but even distracting. Quite recently I was listening to a speech by a well-known English poet. What he had to say was highly interesting, but at regular intervals in his speech his right hand sought the back of his head and gently patted it in order apparently to ascertain whether he had lost his back hair or not. Such a proceeding might possibly be justifiable in the case of a veteran like myself, but it was a highly unnecessary precaution in one so young. One ended by being, as it were, fascinated by the recurring action in the same way as one is fascinated by a regularly recurring flash-sign at night—one cannot choose but look—be it Veno's Lightning Cough Cure or Edwards' Desiccated Soup. This capillary attraction (to come back to our poet) grew so overwhelming that the speech became of secondary interest, and one realised once more the profound dictum of Bergson on the comic element that comes to the front when life masquerades as a mechanism.

Possibly the reason for this lack of spontaneity in our gestures is partly physical. Our raw and damp climate which discourages us from opening our mouths so wide as our continental neighbours, lays its rheumatic grip on our muscular activities. But it is also physical. This conservation of physical energy is due to our concentration of will power, our outstanding English characteristic, with its corollary of perpetual self-control of the emotions. We do not let ourselves go easily. We are either rigid or violent. Gesture to a Frenchman, and still more to an Italian, is a second language—a commentary, accompaniment and explanation, all rolled into one, of the spoken word. With an Italian, pantomime and Dumb Crambo are so perfect, that even if you do not know his language you can get hold of the general drift of his meaning. I remember once an Italian singer in Berlin with the two Lehmanns in Don Juan. The two prima donnas, fat, fair and forty, who looked like two deserted landladies, concentrated their artistic efforts on the singing. Not so Andresda; he frisked round them, putting such brio into his attentions that he almost persuaded one they must be beautiful.

But gesture, except of the clown order, in which the Englishman is supreme, occupies a more subordinate position on the English stage, though it is not infrequently overdone. Years ago I asked Coquelin aîné, at the time of one of his visits to London, what he thought of English acting. As

everyone had been so kind to him, he begged me, whatever he said, to keep his opinion private for the time, which I promised to do. He then said that he made the same criticism of Irving and Tree that Garrick made over 100 years ago of the French actors of his day, that they overdid their parts. But over-acting, as a friend has pointed out to me, is like the child thumping the piano, only force ill-applied in the desire to obtain an effect, and as such is indicative of imperfect control of one's own mechanism.

Still, if gesture is only subsidiary compared to its importance in France and Italy, its study is none the less essential not only for actors, but for public speakers, even though it lead to no more than teaching them what *not* to do with their unruly members, be they feet, hands, or head.

II. I pass to Pronunciation—for a long time supposed by the phoneticians to be the end-all or be-all of correct speech. Happily, of recent years, they have gradually realised the supreme importance of intonation, especially from the point of view of musical pitch, which varies for each language. As I take it, pronunciation deals with *correct sound*, intonation with *correct meaning*. The former takes words or syllables as its unit, and the latter phrases or sentences. These two things at bottom represent two totally different things, as anyone who has had to teach a child to read knows. The child may read a passage with absolute correctness as far as sounds go, yet it is so lifeless and mechanical that the hearer is obliged to say it over to himself in order to interpret it, just as we are obliged to say over to ourselves the sounds of some phrase we have heard in a foreign language, if we have failed to understand it when it was uttered. As to the teaching of pronunciation, with which I include enunciation or the art of making clear sounds, that is the business of the voice-producer and phonetician, who should always work together, though such is by no means always the case. Such training is especially necessary for the average English speaker with his blurred vowels and slurred consonants.

III. I pass to Intonation, which deals, as we have seen, with musical pitch and under which, for the sake of convenience, I include pause and stress. The usual forms of affirmation, order or question in the different languages can all be set down in musical notation as well as the ordinary ways of expressing such common emotions as anger, surprise or fear. But intonation is not only this: it seems to me at best something far more subtle, so subtle as to defy any concrete notation. Thus, in the two phrases, "he took a pail and went into the garden," and "he saw a pale face in the garden," I cannot help feeling there is, apart from the stress on the two words, some very subtle difference made by a reader who visualises as he reads, because I cannot believe, if his visualisation of the two things differs that his outward exteriorisation of the two is not also a matter of tone as well as stress. Intonation is above all interpretation.

But the most perfect intonation without the appropriate soul behind it is as sounding brass or a tinkling cymbal. I think that many will agree that Coquelin aîné was in some ways the greatest and most finished actor in technique of his time. I remember seeing him one day in that scene in Thermidor, where they are seeking for the papers of some hapless prisoner to substitute them for those of the hero already condemned by the Commune. At last they come across those of an individual with no family ties or dependants. On the point of making the substitution Coquelin refuses with the simple words "Après tout c'est un être humain," words which always thrilled the audience. Years after when speaking of Coquelin with Réjane I quoted the words to her and said I wondered why Coquelin never attempted tragedy. According to Réjane he had. In the first act he was mediocre, in the second worse, and in the third the audience actually laughed. He never tried a tragic part again. I mention this as it seems to me an admirable instance of the *limits* of technique.

Stress and pause are, of course, important, neglect of them results in such blunders as the child's rendering of the hymn: "Can a mother's tender care cease towards the child she-bear," as she phrased it, and the puzzling remark of a small boy of six to me in Berlin, a brother of Hubermann, the violinist, who, when I asked where he lived when staying in London, said Sixty-Tomarkis Road (62, Marquis Road). Stress again is no simple matter of stress and non-stress. There are probably infinite degrees of stress. A French phonetician has, I think, asserted there are in *indivisibilité* seven different degrees of stress,

but please don't ask me which they are. The whole matter is, indeed, highly complicated, but I hope I have said enough about it to show what fundamental brain work the study of intonation involves.

IV. And, lastly, I come to the question of rhythm, which in some ways seems to me the most fundamental of all, since it is the key to the *mood* of the author under study. Of course, it is not to be confounded with rhyme, on which a few words will be said later on. Still less is it to be confounded with metre.

The supreme quality of rhythm is that, though in verse, as a rule it falls into certain definite generic types, of which metre provides the scheme or skeleton outlines, within those limits it is unique, varying *ad infinitum* for him that hath ears to hear. Indeed, it is no paradox, but the sober truth to say that if one writes a stanza on a certain rhythm one day, it is impossible to write a stanza identical in rhythm to it the next day. It has, of course, a family likeness. It may be better, it may be worse, but it is not identical. One cannot bathe twice in the same river. Rhythm possessed what Bergson calls the irreversibility of life, it is indeed life itself. There are many bits of verse which are metrically correct, but they are not predominantly rhythmical, because they are devoid of life, although mechanically correct. They differ from real poetry as a piece of music played in strict dance time differs from the same piece when played with the endless ralentandos and accelerandos with which its composer has scored it. Of course, in prose the rhythm is freer, but in all good prose it is there, and correct phrasing in the recitation of prose is equally necessary for intelligibility. So many people seem to pause in recitation because they have no breath to go on, or they pause too long, whereby the rhythm is lost. Yet correct phrasing is of supreme importance, because the nearer we get to the author's rhythm, the more faithfully we interpret it, and the more faithful our interpretation, the greater our success in conjuring up in our own souls and in those of the audience the precise waves of emotion that thrilled him when he composed the poem or speech. We thus project ourselves and our audience into the very mind of the writer.

Just before the war there was a well known German phonetician whose name I have forgotten, who went so far as to declare that if you wished to enter into the very soul of a composer you must not only play his works on the same type of instrument as he composed them on, but that you must copy all his little idiosyncrancies as far as they are known, in the way of sitting, method of breathing, etc., in a word, you must attempt to put yourself into his skin. This is probably a counsel of perfection and raises the whole problem in the most acute form of what is correct interpretation, and the part to be accorded to the author, his interpreter, and the nationality of the latter's audience. But rhythm, fortunately, is like the language of music, world-wide in its appeal. Words may lose their meaning in translation, emotions be expressed in different pitch in different languages, but rhythm is a universal idiom.

Perhaps I may add here the promised footnote on rhyme. The principal question from the standpoint of diction is, should it be indicated or not? Rhyme is clearly connected with *pattern*; not to indicate the rhyme at all is to ignore the pattern. Generally, the indication will take the form of stress, slightly greater emphasis being laid on the rhyme, or it will take the form of a slight pause, or of a slight rise in pitch. The mood of the writer will dictate what is appropriate, and appropriate it is sure to be, unless the rhyme has been lugged in by the ears when its inappropriateness will at once be apparent. For reading aloud is the supreme test in this respect. Mr. Montague Summers lately stated that in a rhymed play recently performed by the Phœnix Society the indication of the rhyme by the actor, so far from being a hindrance, had added greatly to the effectiveness of the play.

So far I have mainly spoken of the need of training in diction from the point of view of the stage, because the theatre provides, as it were, a megaphone instance of the need for such training, inasmuch as any defect or shortcoming in the way of incorrect or imperfect speech being magnified a hundred times, so to say, on the stage, is rendered thus far more glaring. But the need for speech training is, as I have intimated, hardly less essential for members of other callings and professions, such as politicians, barristers, clergymen and even for more humble persons, such as lecturers and teachers like myself. Nay, we can go still further and say that it

concerns the entire population, and that our general methods of speech are so defective that, as the Departmental Committee on the Teaching of English has so vividly shown, the whole matter needs to be dealt with in the schools themselves, and that for many reasons, of which I will only take one, which is not utilitarian, and yet seems to me the most important of all.

It is that we have got to recover that joy in the spoken word, which is only second to the joy in song, that the majority of us possess at least in a rudimentary way. We have got to recover that joy in the spoken word which the most cursory reading of the Elizabethan dramatists, from Marlow to Beaumont and Fletcher, shows we once possessed, and which is so prominent a characteristic of the French. This is, no doubt, largely due to their being essentially a social nation, since the two main desiderata for intelligent and pleasant social intercourse are good manners and clear speech. But this does not mean we want to turn the English people into a nation of bores and spouters. I am not, indeed, aware from my intercourse with the French people that they turn out more bores or drivellers than other nations. On the contrary, I would venture to state that their conversation is, on the whole, far more sprightly and intellectual, no matter what class you take, than that of the corresponding grade in English society, in fact, the lower you go the greater the contrast. Broadly speaking, the average Frenchman appears to me instinctively to understand that correct speech and a clear way of putting one's thoughts is a duty not only to one's self, but also to the person one is addressing, such consideration being really one of the essentials of true politeness, which consists in sparing one's neighbours unnecessary trouble. Certainly, such clearness and such consideration tend to foster the particular atmosphere favourable to conversation, which even in these days of cinemas and cup ties, is still our greatest national recreation.

But where in the schools are we to begin? The answer is plain: with the children as soon as they enter, and the sooner the better. For all young children are born artists, and all love words and the sound and music of words, though this love may be crippled and finally crushed by the degenerate speech they hear around them. If we could only keep alive and foster this love of the child for the living word, we should end by raising the level of the stage, just as one of the best ways of raising the quality of the artistic products of a country is to raise the level of taste among those that purchase them. Shoddy goods and pinchbeck gewgaws can only be sold to people who are content to purchase them.

I fear the idea of trying to make every child a speech lover will seem very strange and even absurd to some, and yet I hope to show conclusively it is not strange, much less absurd. We have for some time decided, rightly, I think, that even in our infant and elementary schools every child should be taught the elements of drawing and music, even though the vast majority will never become painters or public singers. Is it not then a little strange that we should still largely neglect the art of speech, which is used every hour of the day and all day, whereas the art of drawing and music enter only incidentally, if at all, into our daily life and conversation? If we try to cultivate the æsthetic sense in our children as far as drawing and music are concerned, why should we not *a fortiori* desire to do so in what is an universal art, especially as we have a language which with its numerous vowel sounds is more rich and varied than any continental language I know of? Does not our present spelling indicate from the mere fact that it no longer represents the sounds of many words how varied once was the music of our speech? Should we not, like the Society for Pure English, make a great effort to save some of that music which still remains in the speech of cultured people instead of allowing perhaps the most puissant language in the world to degenerate into a muddy, monotonous stream of slurred consonants and blurred vowels?

Now I have no intention to-night of trying to explain how all this can be done, because we are fortunate to have in our midst not only the Chairman of the Departmental Committee on the Teaching of English, but other members who will tell you with far greater authority than I how this highly desirable reform may be brought about.

I will now pass to the second part of my paper which is very much shorter and which deals with the need of an institution of higher education where speech in all its developments can be systematically studied and a standard as it were main-

tained, and which might provide training not merely for budding actors and teachers, but also for barristers, clergymen and others who wished to take a course in one of the principal branches of their craft.

You will not, I hope accuse me of wanting to make teachers "stagey" or train clergymen to speak like tragedians, though I am not sure whether the pulpit would not in certain cases be the gainer. The courses would naturally be planned to suit the needs of the different types of students.

One only wonders why the need for such a school has been so long in making itself felt. The present apathy is probably due to the fact that the old teachers of elocution, while necessarily empirical, enunciated their rules of thumb as if they were infallible dogmas. They were chiefly concerned in trying to turn out people who, having lost the major part of their personality in the process, were more or less inferior echoes of themselves, a fault not confined to teachers of elocution. You may, in fact, divide up educationists into those who desire to remake the pupil in their own image and those who wish to give creation a chance. Be that as it may, the deadly uniformity they produced has led to a reaction against all training. Yet a person properly trained, so far from losing his personality, should find that the course of training he has undergone has evolved in him an organ to play upon and express his emotions, in a word a body ready and able to vibrate to the commands of the soul. So far from being an animated phonograph or mere barrel organ, reproducing the mechanical effects of his teacher, he has developed himself as an instrument to express his own originality and that of others.

Does such a school already exist? It does, to a certain extent, in the Central School of Dramatic Art, which is at present housed in the Albert Hall, and which has been largely built up by the devotion and loving care of Miss Fogerty and Dr. Aikin. The mere recital of the subjects on its programme will give some idea of its scope. There are complete courses for men and women students in Dramatic and Stage Training and in the teaching of speech for teachers as well as remedial courses for speech defects (stammering and the like), practice classes in public speaking and debates and single courses in recitation and voice training. It is no mere culture in "*vox et praeterea nihil,*" but all the physical and mental aids to perfect speech are enlisted, such as dancing and fencing on the physical side, and severe intellectual study of the passages for recitation on the mental. A similar training on more directly specialised lines is given for those intending to enter the theatrical profession by that young and vigorous institution, the Royal Academy of Dramatic Art, at which the L.C.C. have just established two special Dramatic Scholarships, the first public recognition, one believes, that the profession has ever received.

What these schools and others are doing is excellent, but is it enough? Can one say that the status they occupy in the educational hierarchy of the nation is really adequate? Is not the moment at hand when they should be definitely recognised as an *integral* part of a national system? Certainly, apart from the epoch making report I have just mentioned, there are many omens which seem to indicate the growing opportuneness for such an incorporation. To mention only a few. The increasing importance assigned to the spoken word in the schools of the nation, the renascence of the dramatic art in the schools themselves and in the country at large, as evinced by the school plays at Gresham School, the Elizabethan productions at Avery Hill and Birkbeck College, the Repertory Theatres, the Stage and Phœnix Societies, the British Drama League, and those numerous bands of village players springing up through the countryside; the rising standard demanded from lecturers, clergymen and public speakers; the foundation by the Poet Laureate of the Society for Pure English and the gradual rehabilitation of rhetoric, so long under a cloud, and last, but not least, the growing conviction that acting, like journalism, is a profession and must benefit by a professional training.

How, then, is such an incorporation to be attained? By the creation of a special faculty in the University, in which speech is studied as a main subject by those intending to go on the stage or as a subsidiary subject in varying degrees by those who are proposing to enter politics, teaching or the church. Such a faculty should work on the one hand in close accord with the phoneticians on the practical side of their work, and on the other with the teachers of music, if, indeed, the latter should not, though already occupying separate institutions of their own, be united as constituent

colleges in a conservatoire of national standing, of which the two institutions mentioned above would also be partners. Too long have the arts and crafts been divorced in this country from our higher literary scientific and technical studies, and their fruitful inter-action thereby largely minimised. Yet who will deny that even in so abstract a subject as mathematics some of the clarity and artistry of expression that distinguishes French mathematical work is not directly due to the artistic and literary milieu in which even French mathematicians are brought up, whether as students of the Ecole Normale or as members of ordinary society? Again, the influence on the arts of the more technical subjects, like engineering and building, is still more patent. It is true we are only dealing here with Diction, but its direct effect on the appreciation of literary work and of composition and essay writing is equally obvious. Everything, indeed, seems to point towards the eventual recognition of a faculty of Diction, whose constituent colleges should be united with the present colleges of music in a national Conservatoire, the whole thus forming part of a national University.

Perhaps some of you may think that the creation of such a faculty is not a matter of immediate realisation, though for my own part, I am convinced that in the long run it is absolutely inevitable. In any case, I believe that a practical beginning towards such a desirable consummation might be made at once by the University establishing a diploma in Dramatic art, as recommended by the Departmental Committee in English. There is already a precedent in the diploma in Journalism that has recently been established. Moreover, it is only a matter of time (and I would add money) before we see the setting up of University Chairs and scholarships in Dramatic Art such as exist in several American Universities. Liverpool, indeed, has already made a start by appointing Mr. Granville Barker to such a chair.

May I add, in conclusion, one word to emphasise the intellectual element in acting, which the "natural" school seem to ignore? Acting, of course, is not predominantly an intellectual art. Temperament is a *sine qua non*, but the finest acting is temperament enlightened by intellect. In spite of the advocates of "naturalness," the real leaders of English acting, the Granville Barkers and Nigel Playfairs have by precept and example shown the importance of the *intellectual* element in acting. You cannot interpret an author with ideas unless you have the trained brain to understand him. Again, we have only to look across the water to see how seriously the best actors take their profession, especially those who have been pupils of the Conservatoire, which serves as the Ecole Normale of the Theatre Français. I am not going to enter now into the defects of this institution, its non-connection with the University and the need of making its instruction more synthetic, I will merely say that so far from such an institution turning out budding actors who think they have nothing more to learn, the exact opposite is the case, as may be seen from a Sarah Bernhardt and a Guitry. I was informed years ago by one of the members of the Bernhardt family that after creating a part, Sarah would, during the whole run, spend several hours every day in sheer hard thinking and experiment, with a view of perfecting her role, and for aught I know, she does so still. Again, only recently I was told of the two Guitry, when they were over here, that father and son are perpetually rehearsing at any odd moment that occurs the particular parts they are playing, in order to perfect some portion or point that did not seem to go well the day before or which they think they can improve. This is the secret that lay behind the extraordinary effect they produced on the audience in such a play as "Mon père avait raison." Speaking for myself, as a mere amateur, I can only say that the first act absolutely thrilled me. I do not think I have felt anything like it for twenty years. One was at once enthralled by the supreme illusion of life they produced, and at the same time transported by the perfection their technique attained. It was a triumph for the conservatoire tradition, "de l'effort et toujours de l'effort," and an object lesson of what a similar conservatoire might do for England.

DISCUSSION.

THE CHAIRMAN (SIR HENRY NEWBOLT), in opening the discussion, said the first windmill which the author tilted against was the school of naturalists—those who told people they had only to be themselves, to be natural—and it was perfectly true that the last thing

anyone would wish an Englishman to be upon the stage was natural. That was a fact, neither complimentary nor uncomplimentary to English people: it was merely a candid and scientific description. As the author had said, when an Englishman thought he was behaving naturally he was either not behaving at all or behaving with a curious abrupt kind of brutality. What was meant by the word "natural?" Man was not merely an animal; he was, of course, fundamentally an animal and had a basis of animality, but when one said that a certain thing was "natural" to man, *i.e.*, highly characteristic of man, one did not refer to that part of him which was purely animal. Now all animals had a behaviour which was natural to them and nobody would dream of criticising it; the natural behaviour of an animal in any circumstances was always simply unconscious ease and, according to its own shape and habits, it was graceful. If man were merely an animal he also would invariably move about easily and gracefully and, in a sense, perfectly, whereas in this country at any rate the exact contrary was the case. It was clear then that man was not primarily an animal Man was primarily a human spirit; the human spirit had been placed in the body of an animal, which did not belong to him and was an exceedingly uncomfortable suit of clothes in which he had to go about for the whole term of his natural existence—in many cases in this country it resembled a strait waistcoat. If, at an age when he was still unconscious, a man had been put into shackles, into an iron mask and a strait waistcoat, in which he could not move as he wished and in which he could not express himself, what would be that man's natural desire? Surely, first of all to discover some means of freeing himself, at whatever cost of labour and experiment and however gradually. That was exactly what had to be done in education. The human spirit wished to be free, but it could not be free until it had acquired that which the author had called a technique of some kind, or, in other words, some knowledge of an art. Nothing would set any human being free except a share in some art; nothing would set an Englishman free in the first and most important way, but some share of the artistic in the way in which he handled his own language, and, secondly, something in the way of manners, *i.e.*, the artistic way of handling the movements of his own body. A very famous Frenchman once said: "Man is always born free, but we see him everywhere in chains." He would maintain, on the contrary, that man was everywhere—in this country, at any rate—born in chains, and he could not be seen properly nor could he realise himself until he was set free, and the only way of setting him free was by some tincture of some kind of art. The author went on to propound a theory of what he called inspiration, that there was something necessary to the action of genius which might be called "taking pains," taking pains in the acquiring and in the exercise of that technique which was so desirable. Personally, he would use the word "Inspiration" for something which came after that, something which was added, something which was not necessarily drawn only from the generalised experience of the race to which he attributed it, but also came from the power of being able to draw upon something rather deeper than the experience of the race, something of that spiritual life which lay underneath the whole race, and which was available at certain times when a man who was working was able, as it were, to put down his pump and bring up something for his own use. Personally, he believed that the secret of all art was that that so-called inspiration, those moments of greater power which came to a man, as it were, from outside, were invariably given to him by accident and that no amount of endeavour would ever succeed with any man in creating one word or one line or one drawing of inspiration of any real original genius, but that when he was doing his best to set himself free, to move as his spirit wished in the sphere of his own art, there would be added unto him something more, something which was quite as much a surprise to him as it could possibly be to his readers or to those who saw his pictures or heard his speeches If that was the author's meaning, then he could say not only that he agreed with it himself, but that it was in accordance with all the highest authorities in the art of which he had some small knowledge, namely, the art of literature. All those authorities, from the Elizabethan period onwards, were agreed that there was such a thing as a contribution from beyond and outside man's own will, and that he obtained that not by waiting idly for it, but by doing his very best and working his very hardest along the lines of the best technique available to him The author went on to touch upon the very different state of affairs existing in the French and the Italian nations, and said that to the Frenchman and the Italian expression by gesture and in a ready and appropriate form of language was native. That was certainly true; there was an immense gulf between those people and ourselves, and that he attributed to a difference in time. English people were the product of a very much more recent civilisation. The French and the Italians had inherited, from a civilisation whose antiquity compared with our own was almost incalculable, a freedom to which only a very small number of English people could attain, and then only at the end of a long life. It was probable that in the mere use of language the best writers in English did attain a freedom which was comparable to that of the Italian and even, in a few cases, comparable to that the Frenchman. It would be noticed, however, that the more perfectly a man wrote or spoke English the more he admired the exquisite instrument of the French language, which was

another way of saying the exquisite precision and delicacy of the French thought. In the matter of gesture, he thought it would not be going too far to say that, with the exception of a very small number of our most distinguished actors and actresses, English people never acquired it at all. There was no reason why, if the French had taken thousands of years to attain that freedom, we in this country, having awoke to our necessities, should have to wait thousands of years before we attained it ourselves. It was possible to learn much more rapidly when one had a vivid example before one and had the will to learn. It was for that reason that he, personally, welcomed the author's suggestion that we should keep a very close observation on our neighbours across the Channel. The author had touched upon another point closely connected with that, the question of rhythm, and he thought that rhythm entirely bore out the author's main argument. Rhythm was also natural to man. Children could be taught to acquire very quickly a taste for rhythm, either in words or in movement, because rhythm was one of the secrets of human life. He did not know why it was so, but there was not the slightest doubt that rhythm was the nearest approach in this world to what was called magic. When the effect of rhythm on the communication of ideas from one man to another was considered, its value would at once become evident. He remembered that when he was an undergraduate at Oxford, a Greek play was acted in the University of Cambridge, and a friend of his, who knew no Greek, was cast for a part, because, owing to his gigantic stature, he was more fitted for it than anyone else. He spoke his part in Greek, the words having been written out for him in English capitals, and he having learned them by heart. When the performance of the play took place, those amongst the audience who knew very little Greek did not notice that anything was wrong, but the scholars who were present detected the fact that what his friend said was quite unintelligible. He pronounced every vowel and consonant as he had been told to pronounce them, and the result was absolute gibberish. Quite apart from whether a man understood what he was saying or not, the effect of the rhythm, the effect of what might be called the sound of the meaning, in English prose and in English poetry was of greater importance than anything else. The beauty which was so inexplicable in the best English poems, was not the beauty of the sound as measured by consonant and vowel, nor was it the beauty of the sound as measured by the strict metre in feet in which the lines were written; it was the beauty measured by the sound of the meaning. A writer might produce something which was perfectly correct and expressed his meaning perfectly and yet, although it was written in a poetical form and even expressed a poetical sentiment, it might not be poetry at all, because the sound of the meaning was against it. He remembered a poem published in a New Zealand paper thirty years ago, a poem written with very sincere emotion on the death of a favourite preacher, the Rev. Mr. Kelly, and the last stanza of that poem had remained in his mind ever since. It was a serious elegiac poem, perfect in diction and in metre, but the last verse was as follows:—

"How well he loved in colours warm
To paint yon City fair,
Even it has now an added charm
With Mr. Kelly there."

Whenever there was an intonation in any form of verse which had the sound of a meaning which was argumentative or a definite statement or in any way prosaic, it did not matter what the outward form of the verse was or what the sound of the syllables was—the sound of the meaning was not poetical and therefore there was no beauty in the poem. In Milton's beautiful hymn on the Nativity there were curious lines which always haunted the reader, although they appeared to have nothing but plain prose in them:—

"The shepherds on the lawn,
Or ere the point of dawn,
Sat simply chatting in a rustic row."

Anybody would say that "chatting" was a highly prosaic word, the word "simply" was almost slang, and "rustic row" was very ordinarily alliteration, but that line in that stanza had an extraordinary charm which had lasted for three hundred years.

The last and most important part of the paper was that in which the author spoke of the necessity of something being done in this country for speech training and the method of doing it. The necessity would probably be admitted. There was one reason for that necessity which the author did not mention, namely, that speech was of all the arts the one most essential to man, because the life of the mind could not exist apart from speech. A critic in the "Spectator" who, he thought, was rather more anxious to make a point which nobody else had made than to put forward a very serious proposition, criticised the report of the Committee on the Teaching of English by saying: "There is not one word from beginning to end of these four hundred pages which can show that the Committee have ever given a moment's thought to the question of whether there might not be found some other fundamental basis for English education rather than the English language and literature. Why, for example, should not music be the fundamental basis of every child's education?" The answer was of course obvious. Music was very valuable, but before one could do anything else in the way of living one must begin to live by communicating with other human beings, and language, not music, was the method of communication. The result was that until one could use the three

hundred words that the inhabitants of Suffolk used to be content with in a better way than merely saying Yes and No, one was not fit to take one's part in a society, and a society was not only the end of man's existence but was the only means of his existence as man. There was no doubt that the Latin civilisations were based upon that principle; it was their history, their justification and their glory. It was only necessary to walk into an Italian or French town and listen to a conversation between two of the inhabitants to see the whole of their life and to realise that they were a society and had been a society from time immemorial. The result was that which he had already stated. If English people were to attain to anything of the same kind they must not only have lessons but actually practise the art of life. They must be urbane; they lived in cities so why should not they behave as if they lived in cities? They did really desire to know each other and to know themselves. Personally he fully believed in the desirability of establishing a Conservatoire, and he had seen some teaching in London which was of especial value, such, for instance, as that of Miss Fogerty, who had achieved a miracle and achieved it so perfectly that her pupils appeared, after a very short training to be literally acting and speaking with perfect naturalness, a naturalness which was the result of the extreme perfection of the teaching they received. Quite apart from that, he thought it was very desirable that all over this country those who taught anything anywhere should be in very much closer intimacy with one another and also with other persons who were not teaching but were likely to belong to that body of citizens who it was generally agreed were the only arbiters of such things as pronunciation. Wherever one went in English society one found sects slaughtering the English language by mispronouncing it. He believed, however, it was agreed by every authority that there was only one standard of well-spoken English and that was the standard of the "best society." What the "best society" was one need not enquire; it certainly was not any society that could be named. He did not blame the teachers, because they had not the power of taking the initiative in the matter, but he blamed the inhabitants of this country belonging to what were called the upper classes or the educated or cultivated classes, because they did not often enough include amongst their friends and amongst their guests the teachers who lived near them. A very distinguished man, a Cambridge scholar and a Judge, had said to him that day, when speaking of the English teacher, "It is unfortunately true that, although we cannot afford it, we must pay our teachers highly because nobody in England is estimated socially by any other standard than the amount of his screw. If we do not pay our teachers better than policemen you cannot expect people to think much of them, and that is why it has been necessary to raise their salaries. The moment it is ascertained that a man or a woman is a teacher, he or she becomes a cipher and ceases to count in the social system." That was the national failing of this country and it was the one real kind of snobbery which existed amongst us, the snobbery of thinking that material welfare and wealth were the measure by which not only to appreciate ourselves but to depreciate those whose intellect and education were often superior to our own. The work of teachers should be recognised not only by giving them higher salaries but by honouring in every way those activities towards which teachers were leading: for instance, not to speak of children's time being wasted or the taxpayers' money being wasted by the children being taken to see Shakespeare's plays, but honestly to believe that they went there for much the same reason that other people went there—for that intellectual enjoyment which was one of the highest functions of life

Miss Elsie Fogerty said she was an Irish woman who had been to a great extent educated in France and was fortunately bi-lingual. A great part of her training was carried out under the ægis of the wonderful Conservatoire to which the author had referred, and she hoped that a similar one would be established in this country, but on the present occasion she wished to stand up as a champion for the dramatic gifts and possibilities of the English people. It must not be imagined that, because the people of other lands had a certain external facility in outward expression, that was necessarily the right and proper way for the people of this country to express themselves. She felt that an English audience deserved most of what had been said that evening and that our level as a nation was low, but she did not believe that we were behind in genuine dramatic expressiveness. Perhaps she might claim to know a little about the subject, because she had taught people of three nationalities. She once went to a small German town, where she was enormously impressed by the vivid expressiveness of the tragedian of the evening. The next day she lost her trunk and the station master acted in exactly the same way, and she did not feel quite so much respect for the tragedian's expressiveness after she had seen the station-master tearing his hair on the platform. It seemed to her that in art levels of tone were the real question; not whether one had attained the highest possible degree of power and intensity but how completely one had measured the degree of variety that one obtained. She would be glad if the author could give a rather more fundamental view of what rhythm was. It had been said that rhythm was near, to life, but she thought it was more than that and that rhythm was the fundamental law of movement, exactly as gravity was the fundamental law of stability. Rhythm was really the synchro-

nising of time, of force and of space under the direction of intention; the English feeling for rhythm was almost the strongest in the world. In proof of that, she would urge the capacity of English people for games and also the fact that their poetry was less metric and more rhythmical than that of any other nation. After all, had they really failed in that side of art? Surely the language, the training, the achievements which had given the English people their literary history from Chaucer to the present day could not be accused of any lack of that essential and fundamental sense of rhythm. What the people of this country must be criticised for was exactly what the Chairman had mentioned—a certain fundamental scorn for artistic expression. The greatest service that a Conservatoire would render to this country would be to give back to the people more of their heritage of freedom. Though it was quite true that Garrick said that French actors exaggerated, yet Talma, one of the greatest actors of the end of the eighteenth century, who founded so much of the quiet, reserved greatness of French acting, himself learned a good deal from Garrick She believed the English people had an infinite capacity for dramatic expression, but that they must find it in the genius of their own tongue They had to speak the flexible, free, five accent rhythm of blank verse, which was never equal in its two halves, whereas in France thay had the Alexandrine metre and thus had a stricter, a more regular and a more metric problem than the rhythm which was required in such lines as: "Ye elves of hills, brooks, standing lakes and groves," with their wonderful median pauses She thought the people of this country should not disparage their own dramatic and rhythmic gifts.

Mr. George Sampson said he wished to emphasise, from the point of view of a schoolmaster, what had been already said It was just 52 years since the first Elementary Education Act was passed in this country, and now the axe had been laid to the root of the whole system His school happened to be in the neighbourhood of Sloane Street, and he heard a good deal of what might be called the Lowndes Square view of life. On the previous day he had been talking to a lady about the "cuts" in education, and she said, "What we have to give the children of the working classes is a good plain practical education with no trimmings" He asked her to explain what she meant by "trimmings" and she replied: "Music, literature, and all that sort of thing." Again, the Member of Parliament for his own constituency said recently: "What is the use of our giving everybody an education? After all, there can be only one Lord Chancellor," and there was the now immortal Alderman McArthur of Cambridge, who asked, "What is the use of education to a man who is going to hold the plough or to spread manure?" Questions like that really went to the root of the whole matter. What were we trying to do in the schools? Were we trying to make education a contribution merely to those hours of a man's life which were not his own, which he sold to someone else, or were we trying to make education a contribution to the whole time of a man's life? That was a question about which we must think seriously. Speaking as a schoolmaster, who had worked for 27 years in different parts of London, he could say that he was still an optimist He believed that a teacher must very often turn his eyes away from the factory and the workshop and look in the direction of the City of God, and see before him, when he looked at his assembled school, not so many heads to be stuffed but so many souls to be saved. He would find his school to some extent a collection of inarticulate beings and the beginning of their education must necessarily be in their language, which was their tool and the instrument for everything they would have to do. The beginning of language was obviously speech, and the beginning of speech came at a very early age Speech training, as the author pointed out, could not begin too early. How little used to be thought of speech training could be gathered by the fact that his own education as a teacher took no notice of the subject at all. There had been an improvement since that time, but even now the position in regard to that matter was not nearly as good as it should be. One thing that teachers lacked was a standard, as the author had said; they did not know where to look for their standard speech. They could not look to the stage for it, as in France. The foundation of national speech must be laid in the school Exactness of speech was not a trimming, it was not a mere negligible extra in the school of life It went down to the root of the whole matter, because the different classes in this country spoke different languages. The country was sundered by chasms across which the classes were glaring at each other almost with hatred, and that hatred would deepen and those chasms would widen as long as the speech of the classes was different. An endeavour must be made to teach the children in the schools standard English. Although it was difficult to say what standard English was, teachers knew what was not standard English; as a rule they could tell a breach of standard English when they heard it, and he thought for them that was a sufficiently good working basis There was another way in which the speech of the country could be improved, i e., let the Board of Education insist that in all the schools of this country some approach to standard English should be required. By that means, standard English would not be obtained in a generation, but an effort would be made in the direction of obtaining it. He believed very firmly that to teach children to produce correctly the sounds of the words they

used and to approximate their speech to the normal speech of this country, was really not an educational fad but a great social remedy.

MR. KENNETH BARNES said he agreed with nearly everything the author had said, but he felt there was a danger of separating speech from thought. The only speech that was worth anything was that which expressed a thought, and nobody could be said to be really eloquent unless he had behind his speech a live idea. The disadvantage of speech training was that it sometimes gave the pupils the idea that there was something in the actual speaking of the words that made them charming. It was most important to realise that words were, so to speak, current coin; they were not of value in themselves. With that restriction, he felt that all the author had said was true. The children in the schools must be taught how to speak so that they would grow up with the right tradition of English speech, and then when they left school they would not need the very special training that they required at the present time if they were to speak well. He thought that, until there were sufficient teachers to teach those children in the schools, some movement to obtain a special class of teacher for the schools would be a very good thing The subject in which he was interested was the drama, and he wanted people on the stage to set a right example in their methods of speech At the Institution of which he had the honour to be the Director, everything possible was done to ensure that. There were many difficulties Very often a student who had been well taught in a school would be mismanaged by a stage manager, and on the stage people had to do all kinds of things in the way of spontaneity and so forth which they had to make appear natural when they were not natural. There were, therefore, many complications in regard to speech training for the stage, perhaps more complications than there were in regard to speech training for public speaking. His Institution was doing all it could to raise the standard in that direction and he hoped it would be successful.

MR. W. SHARMAN (President of the London Teachers' Association) said he thought the author had dealt with the subject so well that there would be general agreement with the statements made in the paper. Speaking as a teacher, teaching working class boys, he wanted to thank the Chairman for what he had said that evening, and also for what had been said in the Report of the Committee on the Teaching of English, that the boys in the poorest schools had a birthright in the English language.

DR. W. A. AIKIN said that many years ago he was struck by the fact that there were so many different opinions as to what was good speaking and what was not, that he determined to set himself the task of doing all he could to elucidate the matter, and he came to the conclusion that, from what was known of physiology and psychology and the laws of sound and the laws of voice, a general principle could be framed by which people could be taught to speak. Twenty years ago he had the privilege of speaking at a meeting of the Society of Arts, on the subject of phonology, which was something more than phonetics or mere pronunciation or inflection and dealt with the humanity of the voice, that which spoke as the utterance of the individual. After a number of years of teaching, he found that the best thing to do was to supply the individual with a really phonological control over his powers of making sound. He quite agreed with Mr. Barnes' remark that every speech should represent a thought, and what could be done in training was to supply each individual with the instrumental faculty of making sounds that might express his thoughts That was what the Central School of Speech Training was trying to do—to give its pupils instruments upon which they could play their language, including what their own emotions and thoughts and imaginations might provide, as well as the general inflection of the voice and the proper pronunciation He felt that the School had already made great progress It was only by education that people learned to use correctly the vocal instrument in the faculty of speech. No one spoke naturally; speech was a thing that had to be learned laboriously in early years. If people learned to speak properly so that they made the most of the sounds they were capable of producing, then pronunciation came as the refinement of speech. Pronunciation was not the important thing; the important thing was that each individual should be able to express himself or herself in sound to the ears of other people, so that they might communicate their thoughts, whether their own thoughts or the thoughts of the great dramatists whom they at the moment represented. There were now general principles; there was a standard not of speech or pronunciation, but of voice use, a standard of instrumental efficiency by which each individual could make himself or herself understood.

MR. J. W. SAMUEL said he wished to express his gratitude to the author for what had been said in the paper. He thought it should be realised that those who taught in primary schools had been stifled for years by Departmental prescription and those who taught in secondary and high schools had been fettered for years by the stupidity of the classical tradition enforcing its rules upon a language it should not be allowed to govern. It was only within the last few years that teachers had been

relatively free to handle English in the way in which scholarship and investigation showed that it should be handled. He was glad to take the present opportunity of saying that, in so far as the Report of the Committee on the Teaching of English was an expression of the newer order of things, and an indication of the way in which that newer order of things was to be developed, the teachers of the country were greatly obliged to the Chairman. Efforts towards the establishment of a Conservatoire and the other steps mentioned in the Report were bound to multiply and out of them much good would come.

MR. CLOUDESLEY BRERETON, in reply, said he was very grateful to the Chairman for having raised the question of inspiration and technique. Evidently he had not made himself quite clear, for his point was that technique was, as it were, a sort of training, and it was only when one was really trained that one could run the race of inspiration. With regard to cultured speech, that was an extremely thorny subject. Personally, he did not think that the most cultured speech was always found at the top of English society, in fact, if the speech of that class of society was analysed it was found that from a phonetic point of view it often left much to be desired, but it was a very good instance of how intonation compensated for that. He thought a standard of Southern English might be obtained. People from Scotland thought that those who lived in the South spoke a very debased dialect, but the latter were in such a great majority in England that they could afford to treat that accusation with more or less complacency. There was one thing, however, which was done in France and which he thought might possibly be done in this country, i.e., to obtain something like a standard pronunciation for the training colleges. In France there was no attempt to stamp out local dialects, and he was sorry that more was not done in this country to preserve dialect, but what was done in France was that the teachers in the training colleges were taught a standard French which they taught the children. It was very important that if the children in France moved from one Department to another they should be able to make themselves understood, the dialects in France being even more different from one another than was the case in this country. He was very grateful to Mr. Barnes for bringing out the point he tried to make at the end of his paper about the necessity of cultivating the intellectual side in acting, which was another way of saying that speech without thought was of little value. There must be hard thinking before a person could really give the right intonation and speak his lines in the right way.

On the motion of THE CHAIRMAN, a hearty vote of thanks was accorded to the author for his interesting paper, and the meeting then terminated.

CHOTA NAGPUR AND ORISSA

The province of Bihar and Orissa falls into two fairly well-defined parts—Bihar, and Chota Nagpur and Orissa. The geographical division between the two does not quite follow the political boundary; but the contrast, for all practical purposes is complete.

Bihar proper is a purely agricultural tract, which, except on the northern and southern borders is an alluvial plain. Every available acre is cultivated by the teeming population, and save in Purnea and Champaran, there is little or no forest and hardly any pasture land. The industries are based on agricultural products or the needs of agriculture, the chief of these at present being sugar-making, oil-pressing, indigo manufacture, and the production of saltpetre and sodium sulphate. Others of importance that may develop in the future are tanning, jute and linen manufacture, rice hulling and the production of fertilizers.

Chota Nagpur and Orissa have a very different future, and practically the whole area is an undulating laterite formation. Of the total area of 69,468 sq. miles a large part is under forest; the bulk of the population is without labour prejudices, and, it would seem, expressly planted there by Providence for the development of the mineral wealth of this tract.

Large portions of the area are as yet without railways, there are few roads and the main rivers are only navigable for a portion of the year. The Orissa coast tracts are traversed by the main line to Madras, which has but one branch to the coast - and that to Puri where no harbour exists. The harbours of False Point and Chandbali, such as they now are, are not connected with the hinterland by rail, nor can they accommodate ocean-going vessels of deep draft.

This undeveloped country contains nearly all the coal and most of the iron ore located in India, besides other minerals such as copper, chromite, mica, limestone, manganese, monazite, graphite, bauxite, china-clay and fire-clay. Its main importance lies in its coal and iron deposits and their juxtaposition. Of the coal fields now worked, those in Bihar and Orissa yield nearly 70 per cent. of the total output of India; while if the Raniganj field is added, the production in the two provinces would amount to no less than 90 per cent. of the whole. The Jahria field alone produces over 50 per cent. of the coal raised in India; while the Bokharo mines, which are in process of opening up, will soon add largely to the total.

In addition to the existing fields, quantities of first-class coal have been located to the west. In the north and south Karanpura fields, huge deposits of coal are available, outcropping to the surface in thick seams. To the west again are the Aurangar and Hutar fields forming the end of a long chain towards the Daltonganj. To the north of Dhanbad is the small Giridh field, at present worked by the East Indian Railway and

producing some four per cent. of the total output of India, while far to the south lie the Hinginrampur mines near Samalpur and the newly proved field at Taloher in the Feudatory State of that name to the north-west of Cuttack.

The important deposits of iron ore hitherto located in Chota Nagpur and Orissa are in the Kolhan sub-division of Singhbum district and in the states of Mayurbhanj, Keonjhar and Bonai. The deposits of Badanpahar and Okampad are extremely rich, averaging over 60 per cent. of iron and in some cases as much as 67½ per cent; but they are small in comparison with the vast deposits that have recently been located in the Kolhan and north Keonjhar. The north west corner of these deposits had been worked for some years by the Bengal Iron Co., but the quality and extent of the ore to the south was unsuspected. Recent discoveries have shown vast deposits of hematite ores in quality equal to the Mayurabhanj ores and in quantity only to be reckoned in thousands of millions of tons. The development of these ores and the linking up with the coal fields to the north, where coal suitable for blast furnace coke is available, is now in progress. Extensive limestone deposits, suitable for use as a flux in metallurgical operations, are found in Gangpur State to the west, close to the Bengal Nagpur Railway main line.

The Bengal Iron Co have settled down to a solid prosperity based on the production of pig-iron and castings made from it. There are now five furnaces, four always in blast, with a daily output of 450 tons of iron. The iron foundries cover an area of approximately 120,000 sq.ft. and include pipe foundries, iron sleeper foundries and a foundry for special castings.

The well-known Tata Iron and Steel Works obtain their iron ore from Mayurbhanj, their limestone flux from Panposh and Rajgangpur, and their coal from the Jharia and Raniganj fields. The plant at present consists of three blast furnaces, with a capacity of 900 tons of pig iron per diem, and seven steel furnaces capable of producing approximately 17,500 tons of steel ingots per month. In the rolling mills, steel rails, joists, angles, channels, tees, etc., are produced. Further extensions are in course of erection. Two more blast furnaces, capable of producing 1,000 tons of pig-iron daily, are nearing completion. Further, the erection of a plate mill has been completed.

Besides the two existing iron and steel companies, three more large concerns and one smaller one are being planned.

The only other metallurgical industry which seems likely to succeed at present is the production of refined copper. No attempt is being made to refine the chromite and manganese ores occurring in the district, although they are mined and exported, or else used as a refractory material. The main sources of supply for refractory materials, such as fire-bricks, silica bricks, etc., are the north east corner of this area where the works of a number of concerns are situated. Another subsidiary industry is the production of coke in by-product ovens. A number of these ovens is now in existence at Jamshedpur and Giridih and in the Jharia coal-field itself. The total output of ammonium sulphate and tar during 1920 is reported to have been 3,720 and 8,880 tons respectively.

MANUFACTURE OF MILK PRODUCTS IN AUSTRALIA.

Although the manufacture of preserved milk and milk products is of relatively recent origin in Australia, the industry is now an important one. As it provides an outlet for the Commonwealth's great dairying and pastoral interests, a large local trade and a certain amount of export business has been built up. While a considerable part of the machinery in use is now being manufactured in Australia. the developing needs of the preserved-milk industry will require the latest and most scientific machines from abroad.

According to a report by the United States Consul at Sydney, the total present turnover of the principal plants in the Australian milk-preserving industry is estimated to be about 34,000,000 gallons of fresh milk, while the annual output of the factories during 1919 was reported to be worth £2,140,470. The amount of capital invested in the industry at June 30th, 1918, was £1,822,017, and about 3,000 hands were given employment. The existing factories are principally in New South Wales and Victoria, but others have been established in Queensland, where there should be good possibilities for development.

Up to about 30 years ago the condensed milk used in Australia came from Switzerland and the United States. Earlier attempts to establish the industry in Australia were not uniformly successful, largely because of defective manufacturing methods. The past three years, however, have seen great advances, and in one product—sweetened condensed milk—the Commonwealth is now on a sound and successful producing basis. By degrees the manufacture of other milk products—concentrated milk, unsweetened condensed milk, dried (or powdered) milk, lactose and lactogen, and infant and invalid foods—has been undertaken and made very satisfactory progress.

There are three or four Australian factories at present manufacturing dried milk on a large scale. Since they are operated in conjunction with other branches of the milk-preserving industry, the output is not known, but the consumption of dried milk is rapidly increasing, and the demand shows signs of further extension.

Before the Great War lactose was imported from the Netherlands, but a large factory for

its manufacture is now in operation in western Victoria, with a producing capacity equal to all local needs.

Infants' and invalids' foods are now being made in Australia, corresponding in their composition to most of those imported. This is the newest and smallest branch of the milk-products manufacturing industry, and it will prosper if local preference for the imported article can be successfully overcome.

The following are the official figures, covering the fiscal year ended June 30th, 1920, for the production of condensed and concentrated milk and other milk products:—New South Wales, 12,969,679 pounds; Victoria, 44,219,389 pounds; and Queensland, 9,170,034 pounds. (The Queensland figures are for the calendar year 1919.)

USE OF TRACTORS IN PERU.

The increasing importance of tractors in Peru may be best realised by comparison of the number imported up to 1919, which was 382, with the number imported during the first four months of 1920, which was 271. At present, writes the United States Trade Commissioner at Lima, there are in Peru nearly all types of tractors—European as well as American There seems to be a marked prejudice, more among dealers than buyers, against tractors of the caterpillar type. However, it is interesting to note that in the northern region of Peru, in the neighbourhood of Paita, where the soil is sandy, the wheel type tractors have been unable to produce results,and a number of small tractors of the caterpillar type are in use and working very successfully.

In Peru, sugar and cotton are not replanted each year, one planting carrying through for several years. The land requires cultivation, however, for while it is fertile it is inclined to harden, and thorough breaking is necessary occasionally. This hardening is inevitable in the case of irrigated lands, such as are all farm lands on the west coast of Peru. Therefore, the question of service is a very important one in these irrigated districts. Every farmer usually has a certain fixed amount of water available each year, and the practice is first to irrigate the field before ploughing. If the tractor breaks down just at the time when he has the field irrigated, and he is unable to get the service that will enable him to place his tractor in working condition within a reasonable time, he is in great danger of losing the use of the field for the season. If the land is ploughed while dry, it is likely to break up in large lumps, making it very difficult to prepare the proper seed bed. One reason why tractors are so popular in the irrigated district is that a farmer is enabled to work his land more rapidly than by the use of the animal power, thereby conserving moisture, and since the use of water is restricted, he can by this means work more land with the same quantity of water.

In cultivation, the rows are planted 1.3 metres apart, so it will be seen that the tractors to meet this demand should be of the gauge indicated. A tractor, especially a cultivator, that can straddle a row is particularly desirable. Thus one with a bottom clearance of 20 or 24 inches, or more if practicable, could cultivate both sides of a row at once, even after the sugar or cotton had reached a height of 3 feet or more. As to the size of tractors most in demand, the small 2 or 3-plough tractor, commonly known as the "12 to 20 horse-power" is most in demand, and probably 90 per cent. of all the tractors imported into the country are approximately of this size.

GENERAL NOTES.

The Yield of Egyptian Cotton.—In the current number of the Bulletin of the Imperial Institute, Mr Gerald C Dudgeon, C.B.E., lately Consulting Agriculturist to the Government of Egypt, discusses the causes which have led to the decline in the yield of cotton in Egypt. Whereas during the six years ending 1899 each acre under cotton produced on the average an annual crop of over 500 lb of cotton, during the eight years ending 1913 the average yield had fallen to just over 400 lb, and in 1920 it was as low as 320 lb per acre, the reduction in 20 years thus amounting to 36 per cent. Such a decline, if not checked, must in time have a serious effect on the prosperity of Egypt, which depends so largely on the cotton growing industry. It is pointed out that although the chief causes to which the decline is due have been recognised, the proportionate share of each in the result is often so unduly emphasised as to produce a misleading impression, and this is apt to lead to the adoption of incorrect procedure. In the article in question, Mr Dudgeon places in their true perspective the different factors involved, such as the degeneration of the productive powers of the soil, the ravages of insect pests, and agrarian disturbance. He considers that great improvement would result from the completion of the comprehensive drainage scheme which was inaugurated by the indefatigable energy of the late Lord Kitchener, but was delayed by the War. The same number of the Bulletin contains several other interesting articles, in one of which an account is given of the tall grasses ("giant grasses") occurring in various parts of the Empire, and of the possibilities they offer for the manufacture of paper. Other articles deal with insects which are liable to cause damage to raw cocoa when stored in large quantities, and with the characters and uses of certain New Zealand timbers which are at present little known in this country.

TIMBER RESOURCES OF THE BELGIAN CONGO.—On many occasions, writes the United States Consul-General at Brussels, attention has been called by the Belgian Ministry of Colonies to the richness of the forests in Mayumba, in the Belgian Congo. The richness of these natural resources was really revealed during the war, when it was impossible to buy from Europe the barrels necessary for palm oil. The native woods had to be utilised and thus became known and appreciated, especially for the above-mentioned use. There has been considerable development since then, and now barrels manufactured in Mayumba are well prepared, perfectly tight, and can be compared with the European article. Cabinet wood also is now extensively exported. The attention of the exporters has, however, been drawn by the Belgian authorities to the fact that the exploitation is effected too rapidly, the raw timber not being allowed to dry sufficiently. The value of these woods is shown by the kinds currently exported, among which should be mentioned mahogany, designated by the natives under the name of "kilungi" or "kalungi." The "kambala" wood, which can be compared to oak, is dark yellow when cut, but rapidly becomes chestnut brown, similar to old oak. The "sangamenga" wood, of a brown red colour, which can be very finely polished and is equal to walnut for cabinet-making, is beginning to be utilised. Although the district of Mayumba is not well situated for forest exploitation, the exportation of fine wood is remunerative. The expense of exploitation is very low, and transportation and other charges to Antwerp are reasonable. The various other products obtained and marketed in connection with forest exploitation also contribute towards the general expense.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. :—

MARCH 22.—PROFESSOR A. P. LAURIE, M.A., D.Sc., F.R.S.E., "The late Mr. Holman Hunt's Experiments on the Permanency of Oil Colours." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., in the chair.

MARCH 29.—SIR THOMAS OLIVER, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.) SIR ROBERT ARMSTRONG-JONES, C.B.E., M.D., F.R.C.P., in the chair.

APRIL 5. — PROFESSOR ERNEST R. MATTHEWS, "Coast Erosion and its Prevention." LORD HEADLEY, M.Inst.C.E.I., in the chair.

APRIL 26.– JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the chair.

Dates to be hereafter announced :—

MAJOR PERCY A. MACMAHON, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

PHILIP SCHIDROWITZ, Ph.D., F.C.S., "Recent Developments in India Rubber Manufacture."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock.

MARCH 24.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., in the chair.

APRIL 28.—F. G. ROYAL - DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the chair.

MAY 26. –PROFESSOR SIR THOMAS W. ARNOLD, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced :—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION

Tuesday afternoons, at 4.30 o'clock.

APRIL 4.—LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "New Zealand." COLONEL HON. SIR JAMES ALLEN, K.C.B., High Commissioner for New Zealand, in the chair.

MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)." Date to be hereafter announced.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETING.)

Friday afternoon, at 4.30 o'clock.

MAY 5—PROFESSOR WILLIAM HENRY ECCLES, D.Sc. (London), F.R.S., "Imperial Wireless Communication."

Cantor Lectures.

Monday evenings, at 8 o'clock.

Guy Radcliffe, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

Syllabus.

Lecture I.—March 20.—Historical Introduction. Geographical Distribution of Essential Oils. Methods for Extracting Odorous Oils and Floral Perfumes.

Lecture II.—March 27.—The Classification of the Constituents of Essential Oils. The Cyclic and Olefinic Terpenes and their more important derivatives.

Lecture III.—April 3.—The Derivatives of Benzene. Alcohols. Acids and Esters. Aldehydes. Phenols and their derivatives. Heterogeneous Compounds. The Trend of Modern Research. The importance of the Essential Oil Industry to the British Empire.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

Monday, March 20.. People's League of Health, at the Royal Society of Arts, John Street, Adelphi, W.C., 6 p.m. Sir Frederick Mott, "Mind and Body."
Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. H. Temperley, "The Geography of the Treaty of Rapallo."
Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Graduates' Meeting.) Captain H. Whittaker, "Hydro-Electric Course at the University of Grenoble."
Victoria Institute, Central Hall, Westminster S.W., 4.30 p.m. Rev. R. F. Horton, "Sunday Observance."
British Architects, Royal Institute of, 9, Conduit Street, W, 8 p.m. Mr. H. D. Searles-Wood, "The Building Timbers of the Empire."
University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Prof. H. Roger "Les Fonctions du Poumon."
At King's College, Strand, W.C, 5 p.m. Mr. E. Bevan, "Dogma."
Automobile Engineers, Institution of, Glasgow, 7.30 p.m. Mr. A. A. Remington, "The Design and Function of Laminated Automobile Suspension Springs."
Electrical Engineers, Institution of (Sub-Centre), The University of Liverpool, 7 p.m. Messrs. L. J. Romero and J. B. Palmer, "The Interconnection of A.C. Power Stations."

Tuesday, March 21.. Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.15 p.m. Mr. J. Y. Hart, "Sickness Data of Elementary School Teachers in London, 1904-19."
Civil Engineers, Intitution of, Great George Street, S.W., 6 p.m.
Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. S. Brigden, "Landscape from the Practical Side."
Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Captain A. Carpenter, "The Depths of the Sea."
Automobile Engineers, Institution of, Coventry, 7.30 p.m. Mr. A. A. Remington, "The Design and Function of Laminated Automobile Suspension Springs."
Electrical Engineers, Institution of (N. Western Centre), 17, Albert Square, Manchester, 7 p.m. Mr. J. Frith, "Specifications and Estimates."
Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. M. Thiery, "Le Theatre de Paul Herview."
Royal Institution, Albemarle Street, W., 3 p.m. Sir Arthur Keith, "Anthropology of the British Empire." (Lecture V.)
Zoological Society of London, Regent's Park, W., 5.30 p.m. (1) Mr. Gilbert Blaine, "Notes on the Zebras and some Antelopes of Angola." (2) Mr. R. I. Pocock, "On the External Characters of some Histricomorph Rodents." (3) Mr. H. R. Hogg, "Some Spiders from South Annam."

Wednesday, March 22.. University of London, King's College, Strand, W.C., 5.15 p.m. Prof. Nils Bohr, "The Quantum Theory of Radiation and the Constitution of the Atom." (Lecture III.)
Geographical Society, Burlington House, Piccadilly, W., 5 30 p.m.
Aeronautical Engineers, Institution of, at the De Haviland Aircraft Works, Stag Lane, Edgware, N.W., 3 p.m. Mr. W. O. Manning, 'Sea-plane Design."
Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m.
Oriental Studies, School of, Finsbury Square, E.C., 5 p.m. Mr. M. de Z. Wickremasinghe, "Tea and Rubber Industries in Ceylon."
United Service Institution, Whitehall, S.W., 8 p.m. Commander T. F. P. Calvert, "Old Customs and Expressions used in the Royal Navy."
Public Health, Royal Institute of, 37, Russell Square, W C., 4 p.m. Mr. A. J. Morland, "The Helio-Alpine Treatment of Surgical Tuberculosis."
Industrial League and Council, Caxton Hall, Westminster, S W., 7.30 p.m. "The Rt. Hon. G. N. Barnes, "Some Common Fallacies on Trade and Industry."

Thursday, March 23.. Fine Art Trade Guild, at the Royal Society of Arts, John Street, Adelphi, W.C., 7 p.m. Lecture by Prof. A. P. Laurie.
Royal Society, Burlington House, Piccadilly, W., 4 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.
Child Study, Society of, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. F. Whelan, "The League at Work (League of Nations' Union)."
University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Prof. A. Chauffard, "Syndrome Humoral de la Goutte."
Oriental Studies, School of, Finsbury Square, E C., 5 p.m. Dr. L. D. Barnett, "The Hindu Culture of India." (Lecture IV.)
Mechanical Engineers, Institution of (N. Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m.
Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. S. F. Stapler, "Floating Docks."
Dyers and Colourists, Society of, Bradford. Mr. P. E. King, "Dyeing Artificial Silk."
Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. Mr. C. Duvernoy, "Les Moyens de Defense et d'Attaque des Insectes avec Projections Lumineuses."
Royal Institution, Albemarle Street, W., 3 p.m. Dr. P. Chalmers Mitchell, "The Cinema as a Zoological Method." (Lecture II.)
Aeronautical Society, 7, Albemarle Street, W., 7 p.m. (Students' Section.) Mr. H. S. Evans, "Some Notes on Commercial Aeroplanes."
Brewing, Institute of (Midland Counties Section), Grand Hotel, Birmingham, 7 p.m. Messrs. A. Tait and L. Fletcher, "The Development and Nutrition of Yeast."

Friday, March 24.. Royal Institution, Albemarle Street, W., 9 p.m. Prof. F. G. Donnan, "Auxiliary International Languages."
Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.
Engineers, Junior Institution of, Caxton Hall, Westminster, 8 p.m. "Questions and General Discussion Meeting."

Saturday, March 25.. Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Radio-Activity." (Lecture IV.)

Announcements intended for insertion in this list must be received at the Society's Office not later than the Monday morning of the week preceding the Meeting.

*For Meetings of the Royal Society of Arts, see page 309.

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FRIDAY, MARCH 24, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 27TH, at 8 p.m. (Cantor Lecture.) GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constituents of Essential Oils." (Lecture II.)

WEDNESDAY, MARCH 29th, at 8 p.m. (Ordinary Meeting.) SIR THOMAS OLIVER, M.D., LL.D., D.Sc., F.R.C.P., "Alcohol in relation to Industrial Hygiene." (Shaw Lecture.) SIR ROBERT ARMSTRONG-JONES, C.B.E., M.D., F.R.C.P., in the Chair.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 15th, 1922; SIR ROBERT MOLESWORTH KINDERSLEY, G.B.E., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Roberts, Alfred Edwin Priestland, Birmingham.

Vardy, William Andrew Shakespeare, Normanton.

The following candidates were balloted for and duly elected Fellows of the Society:—

Donald, Bernard Speirs, London.

Seago, Miss Muriel, Harrogate.

A paper on "Certain Aspects of the Problem of Exchange Stabilisation" was read by Mr. Oswald Toynbee Falk, C.B.E.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

On MONDAY, MARCH 20th, MR. GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, delivered the first lecture of his course on "The Constituents of Essential Oils."

The lectures will be published in the *Journal* during the Summer recess.

PROCEEDINGS OF THE SOCIETY.

THIRTEENTH ORDINARY MEETING

WEDNESDAY, FEBRUARY 22ND, 1922.

SIR HERBERT JACKSON, K.B.E., F.R.S., Vice-President of the Society, in the chair.

THE CHAIRMAN, in introducing Dr. Alexander Scott, the author of the paper to be read that evening, said that the Department of Industrial and Scientific Research had recently instituted a scheme for a systematic investigation of the application of science to the preservation and restoration of museum specimens. That was a very extensive undertaking, because museum specimens included practically every material that was known. The Department had thereby performed a notable service to the public; the magnitude of that service might perhaps not be understood for some generations, but that it would be of the greatest value in the present and in the future there could be little doubt. The best scheme of research might have very little chance of success unless the right man could be found to foster and direct it, and the Department had been singularly fortunate in that Dr. Scott had been willing to place at its disposal his exceptional knowledge and wide outlook over the whole domain of science, in order to direct the scheme. Dr. Scott would describe in his paper the great progress that had been already made.

The Paper read was:—

THE RESTORATION AND PRESERVATION OF OBJECTS AT THE BRITISH MUSEUM.

By ALEXANDER SCOTT, Sc.D., D.Sc., M.A., F.R.S.

Before proceeding to consider the subject proper of this paper some points which may be raised in what follows may be made clear by giving a simple definition of a Museum from our present standpoint. A museum is a collection of objects, natural and artificial, brought together into one building from the ends of the earth and removed

from the places where they were produced and stored under conditions usually totally unlike those for which they were individually fashioned. They consist of materials of every conceivable variety, stone or wood, which may be hard, soft or porous, metals which vary in their qualities of softness, hardness and resistance to external influence, clay, baked or unbaked, glazed or unglazed, and so on. It is not only that these objects have been removed from positions and conditions for which they had been especially designed, but that in the ages which have elapsed since they were fashioned, a great majority have passed through a series of situations and changes of conditions which have profoundly modified them, sometimes adding to their beauty, but too often tending to their deterioration and final destruction.

To discuss the methods of preventing, or, at least, completely arresting these latter processes is our present object. We must start with two simple axioms; there is a cause for every change and there ought to be a cure for it.

To get at the cause we must endeavour to arrive at the history of each object and find out what have been the most potent of the agents producing these changes, then we can follow up this knowledge by removing these active substances or of neutralising their action by some kind of antidote. In the thousands of years which have elapsed since man began to make these specimens now stored in the museums of the world, many upheavals of infinite variety—social, political, volcanic, etc.—have taken place. One common result has been that the objects have become buried in the soil at greater or less depths. This, in many cases, has tended towards their preservation, whilst, on the other hand, it has also tended to change many more, mostly for the worse. Ordinary soil contains many agents in relatively small quantity, but which working for hundreds of years bring about wonderful chemical changes. These changes are often aggravated by the removal from a damp or moist soil, of objects, whether of metal or of stone, into a dry atmosphere. The most active of these substances are the chlorides, nitrates and sulphates of sodium, ammonium and calcium.

Had all objects been thoroughly washed and cleaned when acquired and before being placed in cases for study and exhibition, most museums would have been incomparably richer in the possession of precious objects as well as in their being in infinitely better condition. This is well known to all curators of museums, but the infinity of varieties of what we may well call the diseases, as well as the number of places where they have broken out, have until recently prevented a systematic and scientific attack on the many problems which have arisen.

As the great majority of these manifestations of tendency to deteriorate are due to chemical action of a more or less complex nature, the natural procedure is to establish a chemical laboratory where the causes and effects of the various agents at work may be carefully investigated. This has been recognised abroad for many years, as in Berlin, Stockholm and Copenhagen. In Berlin especially an elaborate and carefully designed laboratory for purely museum work has been at work for over twenty-five years. It speaks volumes for the energy of the Director and the staff of the British Museum that such magnificent work on a collection of unparalleled extent and variety has been done without a corresponding adjunct. It can only have been done by wasting the time of the Heads and staffs in each department in getting up details of methods and testing of remedial reagents when such assistance and information could have been given at once by members of a scientific staff. It is as unfair to the Head of a department who has found some of his valued possessions with a malignant disease to perform a crucial operation as it would be to expect the headmaster of a boarding school, having found one of his pupils suffering from appendicitis, to try to remove that boy's appendix in the hope of achieving a complete cure.

A time came, however, owing largely to the war and to the varying atmospheric conditions to which the objects had to be exposed in consequence, when organised scientific assistance became necessary, and in 1920 a small room, which could be used as a chemical laboratory was set apart where the solution of many of the problems could be attempted. It is with what has been done in that room and in this short space of time that we are to deal now.

For many reasons, historical as well as others, it is natural and convenient to begin with objects of stone, as this is the substance ready at hand for the earliest

artificers, and it occurs in an infinite variety of degrees of hardness, porosity and colour. All ordinary rocks are porous to a certain extent, even if we include such a hard substance as agate. The more porous a stone is, the more liable is it to decay, because it is thus able to absorb and retain substances of a destructive nature. Every one knows the disruptive power of water when passing from the liquid condition of water to the solid and crystalline condition of ice. The same effect is produced even if the cause be not identical, when any substance crystallises from its solution, and if this solution is permeating the pores of a solid, such as sandstone, limestone or other rock, and there crystallises, the particles of the rock, especially on the surface, are forced asunder, and a shower of rain washes them away. The soluble and crystallisable material, unless removed, alternates between becoming a solution and becoming crystalline with every period of moist atmospheric conditions, and dry ones, so that a relatively small quantity of such a soluble salt may rapidly lead to the total destruction of a hard stone specimen. The great danger is in this *alternation* of dry and moist conditions, just as in the case of the water pipe which is liable to no change, if kept permanently frozen, or if never allowed to freeze. Just as you may protect your water pipe, as such, by having no water in it, so the specimen may be protected indefinitely by having in it no material which can attract and lose water alternately. The cause of the deterioration is the soluble material, and the cure is the total removal of that soluble material, preferably by washing and soaking first in ordinary water, and then in distilled water. In some cases, the salts in the pores of the stone may be caused to become insoluble, and thus innocuous, but this process often introduces another soluble salt, so that, if prolonged washing can remove the soluble material without injuring the specimen, this is by far the safest and best procedure to adopt for the preservation of the object.

[Here are slides showing an ancient Egyptian vessel of white limestone, with its incrustation of crystalline material, and after the removal of the crust. The fractures produced are clearly shown.]

The porosity of hard stone enables it to store up moisture, and the moisture to extract from the felspar of granite some potash salts, with which to aid the growth of lichens, as the following slides show. This pale grey lichen adhered so firmly to the hard granite rock that attempts to remove the lichen by mechanical means threatened at the same time to remove the pigment. By means of dilute ammonia the lichen was rendered soft and almost gelatinous, whilst the pigment was unattacked, so that gentle rubbing was all that was required to remove the lichen, and to leave the painting unimpaired.

Unfortunately, it is not only paintings on hard rock that suffer from vegetable growths of one kind and another. Especially liable to such growths are water colour drawings, those with chalk and pencil, and even those produced by printer's ink, such as engravings and etchings. There seems to be but little doubt that the cause is due chiefly to the germination and growth of moulds and their spores, these spores occurring in the paper on which the pictures are made. They grow and feed upon—not the cellulose of which the paper is made, but almost entirely on the substances used as size to bind the fibres together and give the paper strength and consistency. These spores and the various bacteria and similar organisms endowed with life, may come from the water used in the manufacture of the paper, but much more probably from the materials, gelatinous and albuminous, of which most sizing materials consist. Given a moist atmosphere, with a suitable temperature, the spores and bacteria have all that is required to enable them to feed on and destroy the size in the pores of the paper. This is easily proved by taking two sheets of the same sample of drawing paper and keeping one in a very dry atmosphere, whilst the other is taken to the seaside for a month or so. If both are now compared by floating on pure water, the sheet which had been at the seaside shows clear wet patches, whilst the other retains its opacity. These clear patches are where the size has been destroyed by growths, and where water now easily penetrates the cellulose fibres. Papers vary considerably in their tendency to show mildew spots due, in great measure, to the more or less drastic bleaching of the paper pulp, the care in the preparation of the size, and the temperature to which the paper has been exposed before finishing. The spots produced are only too often of a brown colour, due

to the substances produced by the organisms. We are in quest of a safe and sure agent which we can depend upon to destroy all such forms of life, without destroying either the paper or the pictures upon the paper. When the picture is in black and white, as in an engraving or etching in which the black pigment is carbon in some form retained on the paper by an oily medium, such as printer's ink, it is comparatively easy to destroy both the coloured products and the forms of life which gave rise to them by means of oxidising and bleaching agents. Personally, I prefer common bleaching powder in dilute solution, in conjunction with dilute hydrochloric acid for this purpose. I have many prints, treated more than thirty years ago, which have shown no tendency to become spotted again in any way, nor has the paper in any way deteriorated. Other reagents which may be used are various *per*-salts, such as ammonium, sodium and potassium persulphates, and hydrogen peroxide.

The solution of hydrogen peroxide as it occurs in commerce is liable to contain sulphuric, phosphoric and hydrochloric acids, as well as salts of barium and other impurities, which are objectionable.

Although the question of the fading of water colours is outside our subject, one commonly employed white pigment, which is liable to change and become black, deserves mention in this connection. This is white lead, which is known to artists under various names, such as "flake white," "ceruse," etc. and chemically as basic lead carbonate. The atmosphere of cities is especially liable to contain small quantities of sulphuretted hydrogen, and this meeting the white lead changes it into black sulphide of lead, thus destroying the purity and appearance of the picture. If we can change the black sulphide of lead into white sulphate of lead, we should be able to restore the picture to its original brilliance. It has long been known that hydrogen peroxide was able to effect this chemical change, but it was, to say the least, rather a risky operation to apply even a purified solution of hydrogen peroxide to the picture. The operation can be carried out with perfect safety by employing, not the solution, but the vapour from a hydrogen peroxide solution in the following way. Prepare a thin slab or block of stucco by casting plaster of Paris in a suitable mould, and after drying the slab thoroughly, distribute over it immediately before use a solution of hydrogen peroxide. Over this block, which must not be at all *wet*, expose the print to be bleached, keeping it just off the block ($\frac{1}{8}$ to $\frac{1}{4}$ of an inch) by one or two threads and leave it for a few hours, or over night, when the black sulphide will usually have entirely disappeared if the medium employed with the flake white had been water, or dilute gum. If resins have also been employed it may require days to restore perfect whiteness. The "foxy" marks so common may also be removed by a prolonged exposure to the vapour.

[Slides to illustrate these actions were here shown.]

Leaving the subject of pictures on paper to those on metals, which might be expected to be much more permanent, we find that here also we have many causes at work which tend to destroy even these. The colouring matters employed in enamels are really varieties of glass coloured by small quantities of the metals themselves or their oxides, silicates, borates, etc. The design is formed by the application of the various coloured glasses in fine powder. When all are arranged the metal and the glass powder are raised to such a temperature that the glass is fused and adheres more or less firmly to the metal. After the fusion is complete the enamel is allowed to cool slowly in either an oxidising or a reducing atmosphere, depending on the nature of the enamels employed. Most metals expand more than materials such as glass: therefore, if an artistic enamel is subjected to changes of temperature, each change produces a corresponding strain between the metal and the various coloured glasses fused upon it. This may be lessened and the strain relieved to a large extent by making the metal very thin, or it may be possible to add certain ingredients to the glasses so as to make them more elastic and accommodating. In time, however, if any large enamel be examined it will be found to exhibit cracks in its own substance, and if on a tarnishable metal, such as silver, discolouration may be traced only too easily from these cracks under the enamel, indicating that the metal and the glass have parted company, and that the air has penetrated this space. Unless one is prepared to take the dangerous and drastic step of trying to remelt the glassy material on the metal, all that can be done is to arrest the further deterioration. This is best

done by means of a suitable varnish applied after all the air possible has been extracted from the crevices between the glass and metal by means of a good air pump, and then before allowing any air to enter to flood the enamel with the varnish. For many reasons a ten per cent. solution of dried Canada balsam in good benzol (not benzoline) was used apparently with perfect success. If the enamel be lifted out of the bath of varnish and simply drained and allowed to dry we may regard the operation as finished, the solution which has penetrated the recesses between the metal and the glass retaining the enamel in its place and preventing it from becoming detached and being lost. The coating of varnish remaining on the outside has also an important function to perform, for it is well known that many portions of enamels and many kinds of glass tend to "sweat" in damp weather. This is due to excess of alkali used to increase the fusibility of the enamel or to other substances to increase the desired effect, whilst incurring the risk of adding undesirable properties. The varnish also adds brilliance and transparency to those parts of the enamel which have become dimmed as a result of the "sweating" and the formation of tiny crystals known as devitrification.

From enamels it is natural to proceed to the consideration of metals themselves, their tarnishing, corrosion and decay. In these respects we have an infinite variety stretching from gold, which may be said to be absolutely unalterable under ordinary conditions, to metals, such as magnesium, calcium and sodium, the last named tarnishing in an ordinary atmosphere as soon as a clean surface of it is exposed. The ordinary metals, which occur and are used for small objects, may be arranged in the following order as regards their permanence under ordinary climatic conditions:—gold, silver, copper, lead, zinc, iron. In addition to the metals themselves, we may have their mixtures or alloys, which may also contain in addition to the above, tin, antimony and arsenic, to mention only three of the most common. Each alloy has its own characteristic stability and corresponding liability to change. Here then, is an inexhaustible field for changes of all kinds and also for research as to what is the best metal or alloy to withstand any given set of conditions.

Pure gold, as already stated, may be said to be quite permanent but as soon as it is alloyed with any of the metals in the foregoing list, possibilities of change arise and the power of resisting change diminishes as the quantities of the added metal increase.

Pure silver, on the other hand, although not readily attacked by a pure atmosphere, is by no means able to withstand the action of common salt in solution, especially if air be present. If the silver be alloyed with copper or with lead, the alloy is attacked with greater readiness, the baser metal being attacked whilst the silver may be left in a more or less coherent and spongy form through the mass of compound formed from the other metals which have lost all semblance of metallic properties.

A search for remedies for the various forms of decay leads to a fairly simple explanation and also correlation of the chief chemical reactions which take place and are the causes of this corrosion. The final agent may be said to be the oxygen of the air, although when dry and pure it would have little or no effect. It is aided by what, if we desire to be fashionable we would call "catalysts," agents which aid and abet the real agents, although in themselves insignificant in amount. Of these, moisture, either as water or as steam, carbonic acid gas and common salt are by far the most important and the most effective in aiding the oxygen in its work of destruction. All three occur in our atmosphere, in our water supplies and in our soils.

The chemical actions are in reality very simple. If we place some pure common salt in a pure silver dish with a little distilled water and leave it over night, we find that the silver has been attacked and a certain amount has entered into solution in the brine. This can be proved by pouring the brine into a larger quantity of water, when an opalescence is produced and can be rendered more apparent by the addition of a few drops of potassium iodide solution. If, however, instead of pure silver an alloy of silver and copper be subjected to the action of moist common salt, we may assume that both metals are attacked, but any silver chloride which may be produced is reduced to metallic silver again as long as any metallic copper remains in the alloy, the silver being brought back from its chloride in a spongy or other more or less coherent form. The action of the air and small quantities of common salt continues until the whole of the copper is converted into a porous brittle mass of oxides, car-

bonates and oxychlorides of copper through which the silver is distributed.

It must not be imagined that this type of action proceeds only in moist soils. Very many objects in museums are thickly incrusted with these chlorides of copper and of iron, and these incrustations, with the assistance of the moisture ever present in our atmosphere, go on quietly with their destructive work, for which they possess all the agents necessary. It is not uncommon to class especially the copper compounds as "malignant" and harmless, and it is often apparent to which class any example belongs by simple inspection by an experienced eye.

The destruction of iron is much more rapid and much more difficult to arrest than in the cases of copper and silver and other alloys.

A word of warning ought to be given with regard to a commonly accepted method of treating iron objects more or less thickly coated with rust.

After washing in two or three changes of water, the specimens are dried and then immersed in a bath of melted paraffin wax at a temperature above the boiling point of water. The hydrated oxide of iron (or rust) is rarely, if ever, heated to such a temperature as to remove all the *chemically combined* water, so the coating of paraffin wax seals it in and in time it and any chlorine still remaining in the coating continue to attack any metallic iron present. The compounds so formed increase so much in volume that the skin of paraffin wax is ruptured and atmospheric air admitted when the corrosion once more proceeds apace.

The real demon is common salt, and its deadly sting is the chlorine which it contains and gives up to the metal. Therefore, if it is desired to preserve any metallic object whatever, it must be regarded as essential to remove from it every trace of chlorine either by chemical, electrical or by some other method applicable to each individual case.

A certain amount of chlorine may be removed by simple washing, but unless we can convert the chlorine in the usually insoluble oxychlorides into a soluble form such as sodium or ammonium chloride, there is but little prospect of success. The objects should, therefore, be boiled with caustic soda solution or with a solution of sodium carbonate or in many cases sodium sesquicarbonate, followed by copious washing as long as the wash waters indicate the presence of chlorine when tested with silver nitrate and dilute nitric acid. Finally, the last traces of chlorine should be urged to leave the metallic object by the application of a weak electric current, so arranged that the specimen is the negative pole and the positive pole a plate of zinc, copper or silver, and the liquid electrolyte either very dilute sulphuric (or other) acid or a weak solution of soda or other alkali.

By careful manipulation it may be possible to remove the chlorine without destroying or injuring the "patina" to any great extent, and it may be possible to restore or produce a patina by such means which will rival that which so far has only been produced by slow action going on for centuries.

In the case of coins and their cleaning and restoration by means of ammonia and acid reagents, it must ever be borne in mind that these reagents in presence of air and oxygen are corrosive agents, that is, they attack not only the impurities on the metal, which are still there, but they attack the metal itself, even in the case of silver. To employ such solutions with safety, there ought to be present also some substance known chemically as a "reducing agent," such as sodium sulphite, stannous chloride and formic acid. The last named of these, formic acid, employed in various strengths seems ideal for cleaning silver objects, especially when used warm. This is due to the fact that silver formate cannot exist at temperatures much above the ordinary, but if formed is destroyed by gentle heat into silver and carbonic acid.

Lead is in many ways one of the most durable and resistant of metals to many powerful chemical reagents. On the other hand it has an "Achilles heel" through which it can be attacked and corroded very rapidly by many reagents usually considered weak. Organic acids, such as acetic acid or vinegar and many fatty substances, behave towards it much as the chlorine of common salt does towards copper and iron. The lead objects contaminated with traces of these substances in presence of air, moisture and carbonic acid rapidly become brittle and more or less shapeless masses of basic lead carbonate (white lead).

The objects so far dealt with, with the exception of pictures on paper, have been what are usually termed inorganic. Besides

stone and rocks early man had another type of material with which to work and which he did employ very largely. In the trees which he saw growing around him he had a large choice of material, much of it in a form in which it was available for immediate use or required but little to be done to adapt it to his varied needs. From its nature it was not to be expected that it would endure as objects of stone or metal. This in itself is enough to warrant our treasuring specimens which have come to us in safety through the ages. One very interesting case which has been successfully dealt with and decay arrested is a set of figures which were presented to the Museum 50 years ago. They were buried under 14 to 16 feet of guano on the Macabi Islands, and as according to Alexander von Humboldt the guano deposit only amounts to a few lines (let it be an inch) in 300 years, we can see that these can boast of no mean antiquity. Their threatened destruction was due to the action of various salts of ammonia combined with the alternation of moisture and dryness of the atmosphere.

Much of what was said about the causes of decay and the preservation of paper applies also to wood. In addition to the destructive agencies of microscopic size are those of beetles and other wood boring insects, the destruction of which calls for other and more strenuous types of poisons which can be relied on to destroy them, and, what is still more difficult to secure, the destruction of their eggs. The destruction of many precious objects of wood and of pictures painted on wood panels, is often far advanced before it is detected. It is to be hoped that in the new laboratory being constructed at the Museum, these and many of the pressing problems requiring solution will be successfully solved.

DISCUSSION.

The Chairman (Sir Herbert Jackson), in opening the discussion, said that the subject of which the author had undertaken the direction was an exceptionally fascinating one. As the author had described it, it sounded very simple, but in reality it called for a very wide outlook on science, not only in chemistry but also in physics and in the biological sciences, and in addition it required a very large amount of common sense and that particular quality which was not easily obtained by training, namely, special sympathy with the subject and a real desire to do the best possible to preserve the very valuable relics contained in museums. Scientific men were singularly modest and looked for very little reward for their labours, but he thought the time would come when the author's name would be blessed by future generations, who, if it were not for the work of the author, would in many cases only be able to read descriptions of the various objects instead of seeing them. The work seemed very simple, but it should be remembered that if a mistake were made it might lead to the destruction of a valuable article. The author said in his paper that this, that and the other were tried, but, if one thought of the recondite science that had to be employed in order to obtain the results he had achieved, one realised how useless research of the kind would be in the hands of a man who had not wide experience and catholic tastes in science.

Sir Sidney Harmer, K.B.E., Sc D., F R S (Director of the Natural History Departments of the British Museum), said he was sure everyone present would agree that the British Museum at Bloomsbury was extremely fortunate in having secured the author's assistance in working out some of the problems discussed in the paper. Those who had been concerned with museums had been aware for a long time of the existence of many difficulties, some of which the author had described, and they had been trying, perhaps in a rather crude way, to find solutions to those difficulties, generally being conscious of the fact that they were themselves insufficiently equipped with regard to their knowledge of chemistry. There was no doubt that, as the author had said in his paper, a great many of those problems were simply and solely chemical. Dealing with the question as it affected the branch of the British Museum at South Kensington, the material there was in the main of an organic nature, whereas the author had been dealing to a large extent with inorganic substances; but to a certain degree the problems at South Kensington were very much the same as those which the author had described. For instance, in connection with the preservation of metals, very much the same kind of difficulties had been experienced at South Kensington as at the Museum at Bloomsbury, great trouble having occurred owing to the alteration of masses of meteoric iron. It had been necessary to find a remedy for that, and there was now an effective method of treating those meteorites so that deterioration by rust was prevented. Another point which had struck him in the paper was the author's reference to the cracking of enamel. Curiously enough, exactly the same difficulty had been experienced at South Kensington with regard to the enamel of teeth. Nothing was more common, when fossilised teeth were dug up out of the ground, than to find that after they had been kept for a certain time the enamel began to chip off in exactly

the same way as did the enamel coatings of metal surfaces described by the author, and the treatment adopted was fundamentally the same. With regard to the question of carbon bisulphide, he thought entomologists might be able to give the author some useful information on that subject. He believed it was well known to entomologists that carbon bisulphide was an extraordinarily effective substance in destroying insects in all stages of their existence, and prussic acid was known to have similar effects. A few years ago he happened to be in Stockholm, and there he saw one of the most beautiful pieces of museum apparatus he had ever seen. It was a large apparatus for treating objects with carbon bisulphide, being in the form of a large horizontal cylinder with a diameter of 9ft The museum to which the apparatus belonged was one concerned with the exhibition of furniture, textiles, and similar things, and it was the practice at the museum to pass through that chamber every single object that came to the museum The process was very much the same as that which the author had described. The air was first exhausted, so that it was all removed from the finest cracks of the object, and when that had been done the carbon bisulphide vapour was admitted to the cylinder A single operation was effective in practically all cases He thought that the problems involved in dealing with organic material were of a more complicated nature than those which the author had described The paper dealt with comparatively simple chemical questions, but, when one was dealing with organic materials as the substances being acted on and with a further organic process concerned in their deterioration, the problem became a much more complicated one He might allude especially to the alterations caused by the action of moulds and bacteria, which were sometimes very difficult to understand. He had in mind a case which had been submitted to the Museum a few days ago of some hose, used in connection with fire engines, which was subject to a mysterious disease resulting in the deterioration of the material of which the hose was composed Similar cases had been submitted previously, and very great difficulty had been experienced in ascertaining the cause of the disease. Up to the present the cause in the case of the hose had not been ascertained, but it was very possibly connected with bacterial action. There was one case he would like to mention in the hope that the author might be able to give some assistance in regard to it; it was very similar to some of the cases described in the paper. The marine shells in an ordinary conchological cabinet, especially the more highly polished shells, such as cowries, were attacked by a disease which caused a thick layer of white efflorescence to appear on the surface, which entirely concealed the shape of the shell. When it was washed off one found that the process had been going on for some time and the whole of the substance of the shell had deteriorated. It was extremely difficult to find a cure for that disease. Various attempts had been made to do so but no one had really achieved any permanent success. The disease only attacked certain shells in a cabinet. In the latest investigation of which he had heard the conclusion was arrived at that butyric acid was in some way connected with the disease, and it was supposed that it was brought about in the first instance by the presence of organic matter in some of the coils of the shell. It was extremely difficult to remove all the organic matter from the shell, and the theory put forward was that the soft tissues left set up various changes which resulted in chemical processes, which in the course of time acted on the shell The author seemed to think that paper which was composed of pure cellulose would not under any circumstances suffer from diseases caused by bacteria and similar organisms. Without wishing to dispute that, he might mention that there was a good deal of evidence to show that pure cellulose, or at any rate the derivatives of cellulose, could be much more nutritious to certain organisms than the author implied. If one examined the conditions under which furniture beetles devoured wood, it was found that the larvæ of those beetles seemed to subsist exclusively on the wood-fibre itself, which, judging from their plump appearance, they must find highly nutritious

Sir Frank Heath, K C B., (Secretary to the Department of Scientific and Industrial Research) said he agreed that those present were deeply indebted to the author for his paper, because, apart altogether from those who were professionally interested as representing museums, most people were to some extent collectors themselves. He thought every dealer in artistic and archæological objects in London ought to have come to the meeting, and he was certain that on some future occasion when the author gave another paper those dealers would attend. The Chairman had said that the Department of Scientific and Industrial Research was to be congratulated on having secured the author's services and gave some indication of the reasons for that, and personally he thought that there was in the author a combination of qualities which it would have been extraordinarily difficult to find anywhere else. Dr. Scott was not only a scientist of very wide knowledge and experience but he was also a collector and an artist and knew the artistic value of the objects with which he was dealing, which was an essential factor in carrying out research where one could not afford to make a mistake. The hopeful point about the experiment—it was very little more than an experiment at the present time—was that, in dealing with a great variety of problems in none of which he could afford to make a mistake, the author had succeeded in finding a solution in a very large proportion of the cases.

That showed how hopeful the attempt was to attack the subject of the restoration and preservation of museum objects in a really systematic way. The Department of Scientific and Industrial Research would have been quite unable to undertake the experiment if it had not been for a combination of accidents, one of which was, as the author had mentioned, the breakdown of museum equipment during the war. The British Museum lost more than one of the men upon whom it had relied for the kind of restoration work described in the paper, and moreover the conditions under which the objects were stored were very much worse during the war than before that time Soon after the war was over, Sir Frederic Kenyon told him of the difficulties he was experiencing and asked him if the Department could do anything in the matter. After certain enquiries had been made and advice obtained from scientists in the Department, it was suggested to Sir Frederic Kenyon that perhaps Dr. Scott might be induced to go to the British Museum so that Sir Frederic might consult him on the subject, and the result of that was an agreement between the British Museum and the Department of Scientific and Industrial Research to begin an experiment on a co-operative basis The Museum provided the accommodation and the Department undertook the maintenance of the laboratory The accommodation at the present time was, as the author had said, very limited, but in the near future it would be much more commodious and more suitable for the extension of the work Sir Francis Ogilvie had just reminded him how true was the Chairman's remark about the unselfishness of men of science when dealing with problems in which they were interested. At the beginning of the experiment the author gave his services freely, and personally, as an official of the Department, he was ashamed to think how modest was the fee that the author now accepted from the Department. It was not a fee that in any way represented the accumulation of knowledge, the time, the ingenuity and the scientific experience which the author was devoting to the work. What were the lessons that the paper brought out most clearly? He thought the first lesson was that if this country was to continue the collection of valuable and often unique specimens, whether of artistic value or of purely scientific and historical value, such as those in the Natural History Museum at South Kensington, it literally could not afford to store those objects without some special scientific control of the conditions under which they were stored. The second lesson, for which there was ample evidence in the comparatively narrow field that had been attacked up to the present, was that before any object went into a museum at all it ought to pass under a systematic review in a properly equipped laboratory. From a financial point of view it would be found well worth while to do that, but before that could be done it was necessary to convince not only the directors of museums, who were as a class intensely sympathetic, but also a rather hard stressed country that it was worth while He did not know what the fate of the Department of Scientific and Industrial Research would be under "the great axe," but if it was left with the power to do so it was prepared to go on with the experiment which was under discussion that evening. That experiment had been centred at the British Museum, partly because the British Museum first discovered the need but especially because there were statutory obligations laid upon the British Museum which prevented any object being removed from its precincts, and therefore it was necessary for the laboratory to be established within the walls of the Museum. He did not imagine, however, that that Statute prohibited objects belonging to other national museums which were under no such statutory obligations being brought into the laboratory, and if other national museums cared to ask for the assistance of the Department he was sure the Department would be quite willing to give that assistance He did not think the Trustees of the British Museum would be reluctant to give their consent to such an extension of the work The author had already described how he had been able to give assistance to the National Portrait Gallery. With reference to the remarks that had been made by Sir Sidney Harmer, he thought the Department might be able to help Sir Sidney in connection with the attack of bacteria upon cellulosic and other organic substances Some extremely important and interesting bacteriological work was done by an officer under the Admiralty during the war at Hopton Heath That work proved of such interest that the Department of Scientific and Industrial Research had arranged a complete interchange of information between the work of that particular investigator and the Cotton Research Association, which was one of the largest of the Research Associations connected with the Department Since the war the Department had arranged with the Admiralty to retain that particular officer in order to work upon the problem of bacteriological attack on cellulosic materials of various kinds, not with the object of finding a means of preserving those materials, but with the exactly opposite object of finding out how cellulosic materials could be broken down in the sort of way that Sir Sidney Harmer had said was such a trouble to him. If an exchange of experience could be arranged with Sir Sidney, it might be found that the organisms which were so troublesome to him were the very things that were being looked for in another connection He never dealt with any of the ramifications of his Department without finding that they led to relations with and effects upon problems and difficulties quite unthought of from the point of view from which the particular difficulty was attacked.

MR. A. F. KENDRICK (Department of Textiles, Victoria and Albert Museum) said he entirely agreed that the Department of Scientific and Industrial Research had found the right man for the work in securing the services of the author, and there was another point he would like to make in connection with that. The author had stated in the paper that certain wooden figures which had been acquired by the British Museum in 1871 should have been dealt with at that time with the object of arresting decay, but, as the author would not have been there to deal with them then, perhaps it was as well that nothing had been done to them before the present time A few years ago he met a well known chemist who was the Director of the Imperial Austrian Institute of Agricultural Chemistry, Dr. Bolle, and, in discussing the subject the author had dealt with that evening, Dr Bolle said he had found a remedy for the beetle in the wood panels of old pictures and that he had been going through Europe visiting the Directors of the various picture galleries and had made converts everywhere he went, the Directors being unanimous that he had found the remedy. Then Dr Bolle had to consider the question of how he was to begin dealing with the collections, and he found the Directors unanimous again—they all said that question would have to be left over for their successors to deal with! Dr. Bolle agreed with them, because he did not think that at that time, ten or twelve years ago, they were ready to begin It was obvious that the scientists were now ready to begin, and, speaking on behalf of those interested in art, he wished to say how glad they were that at last the scientists were prepared to come and help The question of the restoration and preservation of works of art was not a simple matter, even with the methods that had now been discovered. The forces of restoration had a way of deserting to the enemy; there were times when it was found that methods which seemed perfectly safe failed in one way or another To give an instance of that, a few years ago in the north of England there was a tapestry which was a marvellous work of art and had a value of many thousands of pounds. That tapestry was in existence to-day, but it was in two pieces, divided right across the faces of the principal figures in it. That had happened in the following way: The family to whom the tapestry belonged realised its value and as they were going abroad for a time, they took advice as to what would be the best way of keeping it. They were told that a cylindrical metal case should be made, into which the tapestry should be put with a few naphthalene balls in case there were any eggs of moths within the tapestry. That was done, but when the tapestry was taken out later on it was found to be in two pieces. He did not know what had been the cause of it, but it seemed to be due to a kind of collusion between the naphthalene balls and the metal case first of all to attack the metal threads in the tapestry, which were destroyed where the tapestry had been resting on the metal. He supposed such a thing would not happen to-day, certainly not if the advice of the author was taken on the subject. That was a case which showed the advantage of not having started the work of preservation and restoration too soon; if it had been undertaken fifty years ago damage would have been done that would now be irreparable. That work was a great battle, and it was a battle that would ultimately be lost, because Nature had decreed that every thing sublunary should perish; the destruction of the objects could only be delayed and not prevented. He thought it was most important that those who had to do with the preservation of works of art of all kinds should combine together and state what they wanted the scientists to do, because they did not want those works of art cleaned and restored if thereby one iota of their antique artistic value would be lost. When the subject was taken up in that way by both parties concerned, perhaps a new era would dawn.

MR. WALTER F REID said one point that was made clear by the paper was that the Trustees of the British Museum had started a very valuable work, the cost of which was a very small premium for the insurance of the invaluable contents of the Museum. Speaking as a member of the public, he thought the Trustees would be failing in their duty if they did not obtain scientific guidance with regard to the preservation of the objects that were most valuable to the present generation and would be still more valuable to future generations There were one or two points in the paper upon which he did not quite agree with the author For instance, he thought the use of bleaching powder in connection with cellulose was dangerous. In the explosives industry he had had to deal with very large quantities of pure cellulose, and he found that if chlorine was brought into contact with it one could not get all the chlorine out. He strongly recommended the use of peroxide of hydrogen instead; it would do nearly everything that the chlorine did. He did not agree with the author as to the use of Canada balsam for the preservation of enamels. He once made a number of slides for a microscope and used little metal rings in mounting the subjects with Canada balsam; every one of them had corroded and the Canada balsam itself was cracked in all directions and had become dark in colour, although he used the best quality that could be obtained. It might answer quite well at the time, but its effect was not permanent, and he would hesitate to put it in between metal such as copper and the surface that was liable to scale off. With regard to the preservation of wood infested with beetles, he had used bisulphide of carbon for more than twenty years, and had found it

absolutely successful. It must be used at a time when there were no beetles' eggs in the wood, because the eggs were not decomposed or destroyed by carbon bisulphide, and it was also necessary to have the article being treated at a slightly higher temperature than the bisulphide of carbon vapour. If a piece of furniture was covered with a varnish that might be acted on by carbon bisulphide, clearly it would be spoiled if the vapour were to condense upon it. The beetles laid their eggs, generally speaking, at the end of the summer, and now was the time when the grubs did the damage. With regard to Sir Sidney Harmer's remark about cellulose being an article of food for those little grubs, that was not the case. The grubs lived, as Dr. Scott said, on the substances that cemented the cellulose fibres together. In going through museums in this and other countries, one found articles of wood that had been in a very wet condition when they were dug up; they shrank and lost their form, becoming a mere shapeless mass. Some years ago he tried experiments to prevent that, starting with some piles from the lake dwellings at Glastonbury, which, when dug up, were very spongy and soft, but the moment they dried their diameter was reduced to about one-third of the original diameter. They twisted and cracked, and when put in a dry museum they could scarcely be identified by their shape. The method he adopted was a very simple one. He put the wet material, just as it came out of the ground, into a vessel containing paraffin oil, Tea Rose petroleum being what he actually used. Petrol could be used, but it was more dangerous from the point of view of fire. After a time the water was replaced by the oil; the article was put on a grating and the water would be found under the grating and the wood was then saturated with the oil. When the saturation was complete the article was taken out and drained and placed in a vessel with melted paraffin wax. When it was cold it could be handled and had its original form and would last a very long time. He showed that method at a Science Exhibition, and a week or two afterwards he received a letter from the Berlin Museum with two sheets of German forms to fill up. He filled them up and returned them, and received another letter a month or two afterwards containing a cordial invitation to him to visit the Berlin Museum. The next time he was in Berlin he went to the Museum, and when he saw the laboratory there he felt absolutely ashamed of his own country. At that time an extremely interesting subject was being dealt with at the Berlin Museum. The Germans had found in Chaldæa, or somewhere in that region, a very large number of cuneiform tablets. There were several tons of them in great masses, a chamber having been found packed full of them. They were cemented together by sulphate of lime and carbonate of lime, and some of them were insufficiently burned, so that if they were put into a liquid, especially an acid liquid, they went to pieces. The first thing the chemist in charge of the laboratory at the Museum did was to take some small pieces of the clay and put them into a furnace, the temperature of which he could tell by a pyrometer, and he got to within a few degrees the best temperature for burning that clay. Then he put the whole block into a furnace heated to that temperature. Personally, he only wished the British Museum had a furnace it could use for the purpose; the furnace at the Berlin Museum was a beautiful one, heated by gas and with pyrometers and everything that science could devise. When the blocks came out of the furnace they were rather friable; the sulphate of lime was dehydrated and the blocks could be separated into their constituent pieces. They were then put into dilute acid, and when the bricks came out they were quite as bright as they could have been when they were put into the lime. He thought if the British Museum had a chemist who could treat things in that way as they came to the Museum it would be an excellent advance on the present system. With regard to moisture, that could not very well be kept out of an ordinary case, but the Berlin Museum had cases which were absolutely airtight at the top and the lower part dipped into a channel filled with mineral oil. Chloride of calcium or something that absorbed the moisture in the case was put into the case and no more moisture got in, because there was sufficient oil to allow for the expansion and contraction caused by the temperature. The case looked just like an ordinary one, and the objects it contained could be seen beautifully. The subject of fossils was a most interesting one. There were many in the British Museum at South Kensington and Dr. Smith Woodford had shown him a very interesting problem. That problem had to do with some bones that were embedded in fresh water limestone, which was very much harder than the bones themselves. The bones were phosphate of lime and the fresh water limestone was nearly pure carbonate of lime. He dissolved away the carbonate of lime by a very weak acid and at the same time covered over the bones as they emerged with a varnish that protected them from any action on the part of the acid. One of the bones that emerged was the breast bone of a pelican. There was one little residue inside which he could not identify until he examined it under a magnifying glass, when he found it was the bones of the last fish that the pelican had swallowed. With regard to iron, practically all the very old iron articles that were found in the ground were destroyed. An article was dug up that might have been a sword, but outside it was simply a conglomerate of mineral particles held together by oxide of iron. The outer coating could be got off very easily by chemical means. A few weeks ago Mr. Lambert, of the Guildhall Museum, showed him a key and he

found that, after removing a mass of ferruginous concrete, the wards had a thin layer of pure copper in them; they had been cemented or welded together by means of pure copper. No artisan who had ever used brass for uniting iron would use copper; therefore, that key was probably lost or thrown away at the time when copper was used. With regard to bones, people excavated barrows or graves, which contained some of the very oldest remains of the human race, and got very few bones out as there were said to be so rotten that they could not be saved. There was not a single bone found under those conditions that could not be saved. They should be treated *in situ*; the soil and the bones should be hardened together and the bones should be separated out afterwards That could be done with wax, but that was a rather expensive method, and a very simple way was to cement the whole ground together with silicate of soda and chloride of calcium, so that it came out like a rock with the bones in it, and then the bones could be taken out and saved.

Dr. A Scott, in replying to the discussion, said that with reference to Mr. Reid's remarks about Cuneiform tablets and calcium sulphate, he had tackled that problem in the same way as Mr. Reid had described. He did not know when the British Museum would be able to obtain an apparatus such as that at Stockholm which had been mentioned by Sir Sidney Harmer. He had himself thought of a vacuum in that connection and he had thought of carbon monoxide as probably the safest of all the things that could be used and the least likely to attack mineral or other pigments, although modern coal gas might answer in many cases where there were no pigments. He would prefer that to carbon bisulphide. One reason why he had not mentioned certain processes in his paper was that they had been tried for a very short time only and further experience was necessary before they could be put forward definitely. In treating specimens it was essential to have the substances absolutely pure. For instance, in the case of the tapestry referred to by Mr. Kendrick probably the naphthalene used was impure and had a strong smell due to the impurity, and the impurity probably was just the constituent which attacked the metal. When naphthalene was pure it had not very much smell. The same remark applied to carbon bisulphide; if it was used as it was bought it would attack many pigments in a picture He had some carbon bisulphide which he had been purifying with a very powerful reagent since 1911, and it had hardly any smell. He thought it was important to keep on the safe side, and that was why he recommended the somewhat unusual method of using the soda in the form of bicarbonate, because it attacked the articles much less than even the carbonate. His work at the Museum was extremely pleasant and interesting, owing to the variety of the subjects to be dealt with and the assistance given to him by the Heads and their Staffs in every department. He had already learned a very great deal there and he was prepared to learn a great deal more.

The Chairman, in proposing a vote of thanks to the author for his paper, said those present had heard an account of the beginning of what he hoped—if full encouragement and opportunities were given to the author—would become a large school of scientific people who could assist the museums in preserving their material. He hoped it would not degenerate into a method by which, when the way in which decay came about had been discovered, ingenious exploiters might manage to imitate that decay so as to deceive the connoisseurs He was sure that everybody who had any opportunity of exercising influence in any way should do so in the direction of making people realise that it was necessary to do everything possible to utilise science for the benefit of art. He agreed with Mr. Kendrick that it was perhaps fortunate that the work described by the author had not been undertaken before; he had himself seen museum specimens treated 25 to 30 years ago and they did not exist now. Twenty years hence people might say exactly the same thing about the present time. But at no time in the history of science had the important influence of minute quantities been so fully recognised—the progressive action of minute quantities that were less than could be expressed even with many noughts and a significant figure after the decimal point.

The resolution of thanks was carried unanimously and the meeting terminated.

OBITUARY.

Sir Alexander Hargreaves Brown, Bt.—Sir Alexander Hargreaves Brown died in London on the 10th inst., at the age of 77. He was a partner in the banking and issuing house of Messrs. Brown, Shipley and Co. He sat for many years in the House of Commons—from 1868-85 as Conservative Member for Wenlock, and from 1885-1906 as Unionist Member for the Wellington Division of Shropshire. He was formerly a cornet in the 5th Dragoon Guards and was honorary Colonel of the Lancashire and Cheshire R.G.A. He was elected a member of the Society in 1871. He read a paper before the Water Supply Conference convened by the Society in 1878. On several occasions he presided at Ordinary Meetings and took part in discussions.

GENERAL NOTES.

Modern Whaling Statistics.—According to Sir Sidney F. Harmer, K.B.E., Sc.D., F.R.S., in a paper read before the British Association at Edinburgh, the examination of reports by Government officials, supplemented by voluminous statistics which have been furnished by the whaling companies, at South Georgia and elsewhere, to the British Museum (Natural History), shows that there are indications of a serious diminution in the number of whales, in an industry which commenced so recently as the end of 1904. In the case of the humpback, a marked decrease in the number of individuals captured commenced after the end of the season 1911-12; while there is reason to fear that a similar decline in the numbers of blue whales commenced after the end of the season 1917-18 The study of the records of the lengths of fœtuses obtained principally at South Georgia in the south, and from various localities in the north, has led to the conclusion that in each of the three species (humpback, fin whale, blue whale) principally hunted there is a period during which pairing takes place with maximum frequency. In the southern whales the periods in question appear to occur approximately from July to September. and in the northern whales approximately from January to April. If these conclusions are correct, the principal breeding periods, in each hemisphere, are in winter and early spring, when the majority of the whales have left the localities in which they are mostly hunted. Fœtal specimens of a given length are thus most numerous during periods about six months apart in the two hemispheres The duration of pregnancy does not seem to exceed twelve months; and evidence has been obtained that in the fin whale the rate of growth in the fœtus is about two feet a month, during a considerable part of the period of gestation.

New Thread Twisting Machine.—A new twisting machine for the textile industry has been invented by a Norwegian factory owner, according to a report by the United States Consul-General at Christiania. The main principle of the new invention, in contrast to older types, is that the bobbins rotate simultaneously with the spools receiving the spun thread, causing the twisting of both ends (said never to have been acomplished before), which gives greater firmness and strength to the thread. It is claimed that this machime twists seven times as fast as older machines.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

March 29.—Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P., "Alcohol in Relation to Industrial Hygiene." (Shaw Lecture.) Sir Robert Armstrong-Jones, C.B.E., M.D., F.R.C.P., in the chair.

April 5. — Professor Ernest R. Matthews, "Coast Erosion and its Prevention." Lord Headley, M.Inst.C.E.I., in the chair.

April 26.—John Francis Crowley, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." Sir John F. C. Snell, Chairman of the Electricity Commissioners, in the chair.

May 10.—Major Percy A. MacMahon, R.A., LL.D., ScD., F.R.S., "The Design of Repeating Patterns for Decorative Work." Sir Charles Carrick Allom in the Chair.

May 17.—Oswald M. Shephard, "Recent Developments in Rubber Manufacture, with special reference to Rubber Machinery and the Manufacture of Tyres."

May 24.—George Fletcher, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

May 31, (at 4.30 p.m.)—Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

Indian Section.

Friday afternoons at 4.30 o'clock:—

April 28.—F. G. Royal-Dawson, M.Inst.C.E., "The Need for an All-India Gauge Policy." Sir Robert Woodburn Gillan, K.C.S.I., LL.B., in the chair.

May 26.—Professor Sir Thomas W. Arnold, C.I.E., Litt.D., M.A., Hon. Fellow, Magdalene College, Cambridge. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced:—

J. T. Marten, I.C.S., M.A., "The Indian Census."

Dominions and Colonies Section.

Tuesday, April 4, at 4.30 p.m.—Lieut.-Colonel Sir Thomas Bilbe Robinson, G.B.E., K.C.M.G., "New Zealand." Col. Hon. Sir James Allen, K.C.B., High Commissioner for New Zealand, in the chair.

Friday, June 9, at 4.30 p.m.—Major Sir Humphrey Leggett, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETING.)

Friday afternoon, at 4.30 o'clock:—

MAY 5—PROFESSOR WILLIAM HENRY ECCLES, D.Sc. (London), F.R.S., "Imperial Wireless Communication."

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester. "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

Syllabus.

LECTURE II.—MARCH 27.—The Classification of the Constituents of Essential Oils. The Cyclic and Olefinic Terpenes and their more important derivatives.

LECTURE III.—APRIL 3.—The Derivatives of Benzene. Alcohols. Acids and Esters. Aldehydes. Phenols and their derivatives. Heterogeneous Compounds. The Trend of Modern Research. The importance of the Essential Oil Industry to the British Empire.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, MARCH 27..People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Dr. Tregold, "Mental Deficiency."

University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Prof. P. Duval, "Donnés actuelles de la Chirurgie Intra-Thoracique." At King's College, Strand, W.C., 5 p.m. Mr. E. Bevan "Theology." (Lecture III.)

Electrical Engineers. Institution of (North-Eastern Centre), Armstrong College, Newcastle, 7.15 p.m

Mechanical Engineers, Institution of (Yorkshire Branch), at the Y.M.C.A., Albion Place, Leeds, 7.30 p.m.

Chadwick Public Lectures, The University, Birmingham, 7.30 p.m. Sir Arthur Newsholme, "Relative Values in Public Health Work." (Lecture I.)

TUESDAY, MARCH 28..Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Papers by Messrs. E. H. Rayner, J. W. T. Walsh, and H. Buckley, on "The Lighting of Public Buildings, Scientific Methods and Architectural Requirements."

Electrical Engineers, Institution of, (North-Midland Centre), Hotel Metropole, King Street, Leeds, 7 p.m.
(East-Midland Sub-Centre), The College, Loughborough, 6.45 p.m. Mr. A. H. Seabrook, "The Future Aspect of Power Generation."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. J. W. Evans, "Earth Movements." (Lecture I.)

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m. Mr. H. J. E. Peake, "Bronze Swords and the Aryan Problem."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Dr. J. E. Price, "Gelatine."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. M. Thiery, "Le Theatre d'Henry Bataille."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Dr. A. C. Guthrie, "The Advance of Medical Science throughout the Empire."

Engineers, Junior Institution of (North-Eastern Section), Armstrong College, Newcastle-on-Tyne, 7 p.m. Mr. G. H. Martin, "Utilization of Waste Heat."

Chadwick Public Lectures, The University, Birmingham, 7.30 p.m. Sir Arthur Newsholme, "Relative Values in Public Health Work." (Lecture II.)

WEDNESDAY, MARCH 29..African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Sir E. Denison Ross, "Early Travellers in Abyssinia."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Prof. E. Gosse, "Leigh Hunt."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Major I. Salmon, "The Necessity for Educating the Worker in Industrial Economics."

Chadwick Public Lectures, The University, Birmingham, 7.30 p.m. Sir Arthur Newsholme, "Relative Values in Public Health Work." (Lecture III)

THURSDAY, MARCH 30..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Captain G. de Havilland, "The Design of a Commercial Aeroplane"

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Dr. L. D. Barnett, "The Hindu Culture of India." (Lecture V.)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Mr. R. B. Matthews, "Applications of Electricity to Agriculture."

Chemical Society, Burlington House, Piccadilly, W., 4.30 p.m. Annual General Meeting. Address by the President, Sir James Walker. (8 p.m., Informal Meeting.)

Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. M. Hind, "Landscape Etchers." (Lecture I)

Dyers and Colourists, Society of (West Riding Section). Dr. S. A. Shorter, "The Theory and Practice of Piece Scouring."

Brewing, Institute of (Yorkshire and North-Eastern Section). Mr. R. R. Lansdale, "Experiences in Publicans' Cellars."

Chemical Indistry, Society of, at the College of Technology, Manchester, 7 p.m. Messrs. T. H. Fairbrother and A. Renshaw, "The Relation between Chemical Constitution and Antiseptic Action in the Coal Tar Dyestuffs."

Mechanical Engineers, Institution of, Storey's Gate, S.W., 6 p.m. Prof. H. H. Jeffcote, "The Milling of Screws and other Problems in the Theory of Screw-heads."

Chadwick Public Lectures, at the ROYAL Institute of British Architects, 9, Conduit Street, W., 8 p.m. Mr. H. E. Stilgoe, "Water." (Lecture II.)

FRIDAY, MARCH 31..Aeronautical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Mr. Folland, "Aircraft Design."

Royal Institution, Albemarle Street, W., 9 p.m. Mr. A. B. Walkley, "Jane Austen."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. Mlle. G. Latour, "Une Heure de Poesie Moderne."

Philological Society, University College, Gower Street, W.C., 8 p.m. Prof. E. Weekly, "Names."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Students' Section.) Address by the President, Mr. J. S. Highfield.

Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. J. W. Maple, "Engineering in Southern Persia."

SATURDAY, APRIL 1..Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Radio-Activity." (Lecture V.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday morning of the week preceding the Meeting.

***For Meetings of the ROYAL SOCIETY OF ARTS, see page 327.**

Journal of the Royal Society of Arts.

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FRIDAY, MARCH 31, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 3RD, at 8 p.m. (Cantor Lecture.) GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constituents of Essential Oils." (Lecture III.)

TUESDAY, APRIL 4TH, at 4.30 p.m. (Dominions and Colonies Section.) LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "New Zealand." COL. HON. SIR JAMES ALLEN, K.C.B., High Commissioner for New Zealand, in the Chair.

WEDNESDAY, APRIL 5TH, at 8 p.m. (Ordinary Meeting.) PROFESSOR ERNEST R. MATTHEWS, "Coast Erosion and its Prevention." LORD HEADLEY, M.Inst.C.E.I., in the Chair.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 22nd, 1922; SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Jackson, Miss Frances Agnes, Camberley.
Pe, Maung Hla, M.L.C., Rangoon, Burma.
Sarkar, M. K., Calcutta, India.
Smith, D. Curle, M.I.E.E., Kalgoorlie, W. Australia.

The following candidates were balloted for and duly elected Fellows of the Society:

Anderson, Alexander James, C.S.I., Haslemere, Surrey, and Rangoon, Burma.
East, Alan Neville, A.M.I.E.E., A.M.I.Mech.E., London.
Lloyd, Albert Lawrence, London.
MacIsaac, Donald Francis, B.A.Sc., Sydney, Nova Scotia.
Phillips, Frederick, B.Litt., Deganwy, N. Wales.
Sanders, Gerald Worsdall, Apperley Bridge, Bradford.

A paper on "The late Mr. Holman Hunt's Experiments on the Permanency of Oil Colours" was read by PROFESSOR A. P. LAURIE, M.A., D.Sc., F.R.S.E.

The paper and discussion will be printed in a subsequent number of the *Journal.*

INDIAN SECTION.

FRIDAY, MARCH 24th, 1922; SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., in the Chair. A paper on "The Indigo Situation in India" was read by PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

On MONDAY, MARCH 27th, MR. GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, delivered the second lecture of his course on "The Constituents of Essential Oils."

The lectures will be published in the *Journal* during the Summer recess.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post-free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(Joint Meeting).

FRIDAY, FEBRUARY 24TH, 1922.

VISCOUNT ELVEDEN, C.B., C.M.G., M.P., in the chair.

The paper read was :—

LIGNITES AND BROWN COALS AND THEIR IMPORTANCE TO THE EMPIRE.

BY WILLIAM ARTHUR BONE, D.SC., PH.D., F.R.S.,

Professor of Chemical Technology, Imperial College of Science and Technology, South Kensington.

THE ORIGIN AND CLASSIFICATION OF BROWN COALS AND LIGNITES.

Coals may be conveniently divided into five principal genera, namely (A) Brown Coals and Lignites, (B) Sub-Bituminous, (C) Bituminous, (D) Semi-bituminous, and (E) Anthracitic, of which the two first are generally speaking, of more recent origin than the other three. They may all be considered as representing some stage or product of the primary decomposition and subsequent transformation of the vegetable debris of primeval forests and swamps. The process has gone on since carboniferous times in most of the great geological epochs; and, so far as its earlier stages are concerned, it is being repeated in our peat bogs and deltas, where water-logged vegetable debris is decomposing under bacterial influence.

Whilst it is not my object in this paper to discuss the origin and mode of formation of brown coals and lignites, about which there is some difference of opinion, yet a passing reference to the matter will perhaps assist us in judging of their character and value in relation to other coals. From a chemical standpoint, I can see no adequate reason for rejecting the orthodox view that they are intermediate forms between peats and bituminous coals, although our present ignorance of the subject imposes upon us the duty of expressing it guardedly as a provisional hypothesis.

The original vegetable debris from which all coals have been formed, must have consisted for the most part of ligno-celluloses *plus* a certain proportion (probably not exceeding 10 to 20 per cent.) of vegetable proteids. According to Cross and Bevan, ligno-celluloses may be regarded as built up primarily of (1) a lignone portion, consisting of a reactive "keto R - hexene group" and a "furfurose" (*i.e.*, furfural-yielding) complex, combined with (2) α and β cellulose groups, one of which is chemically more resistant than the other. Schultze and Schuppe regard wood tissue as an aggregate of five cyclic cellulose groups ($C_6H_{10}O_5$) and a lignone complex ($C_{19}H_{18}O_8$), the ultimate composition of which would be approximately :—

C=50.0, H=5.75, and O=44.25 per cent.

The debris would also probably contain, besides the foregoing main components, a certain small amount of resins, and it would be mingled with more or less mineral matter.

We must picture then vast masses of such water-logged material, first of all, decaying, either upon the actual site of its original growth (as in a peat bog), or after being macerated into a pulp and transported and deposited by water in some other low-lying swampy area. In this (which may be called the peat-bog stage) it would be subjected to the decomposing actions, both of aërobic fungi and anaërobic organisms, whose relative influences would depend upon the varying water level in the bog; with the result that the larger proportion of it would be resolved into gases (methane and carbon dioxide) and water vapour, leaving an amorphous or gelatinous humic residue comprising the more stable and resistant parts of the original debris *plus* a large amount of water. Some portion of the residue would probably be reduced to a condition of colloidal solution (*i.e.* of a *gel*), whilst the more complex and resistant part would be in a condition of ordinary admixture with, or suspension in, water. Indeed, raw peat in a well-drained bog contains as much as 90 parts of water to 10 parts of the peat substance.

In course of time, this rotted debris would either be overlaid *in situ* (during a subsequent period of subsidence), with layers of water-deposited sands or clays, or be transported by water and deposited in some other lower-lying locality, where it would be similarly overlaid with mineral matter. In either case, under the influence of a slowly increasing pressure, its water-content would gradually diminish, with the result that its combustible matter would be gradually consolidated. Under

such conditions it would be slowly transformed into something resembling the most recent types of amorphous and non-laminated "brown coals," which are of tertiary origin, and usually lie not far below the surface. They still contain a large proportion of water, in some cases as much as 50 per cent.; they are termed Earthy Brown Coals, and are quite devoid of any organic structure. As typical examples may be mentioned (*a*) the Morwell brown-coal deposits in Australia, about which more later on, and (*b*) the German brown coals, which occur in beds of either miocene or oligocene age in Saxony, Brandenberg, and in the Rhine Provinces.

Besides such "amorphous" brown coals, and probably of similar recent formation, there are occasionally found varieties which have a very woody appearance and fibrous structure. As a good example of this class may be instanced the Valdarno deposits which occur in lower Pliocene measures in a mountain chain separating the valley of the Arno from that of Chianti in Northern Italy. Their "woody" character is so marked that they can often be sawn into pieces without crumbling. They have a chocolate brown colour, and in the raw state contain between 40 and 50 per cent. of water. Their outward appearance suggests that they have been formed from wood which, instead of having passed through the usual "peat bog" stage, has undergone a less drastic decay, not involving the disappearance of their woody character. Such fibrous brown coals are a distinct class by themselves, and may perhaps have been formed under somewhat different conditions to other varieties.

In cases where the incipient earthy "brown-coal" deposits became in course of time, buried more and more deeply under accumulations of newer mineral strata, a "blanketting" effect would be produced, with consequent gradual increase in both temperature and pressure. A similar effect would also be produced by earth-movements. This would presumably cause a partial desiccation of the coal, accompanied by certain chemical changes, affecting principally its cellulosic constituents, and resulting in a diminution of the oxygen and an increase in the carbon content of the "coal substance" itself. The deposit would thus become gradually more consolidated; in process of time it might acquire a laminated structure; and with increasing carbon content its colour would darken. Slowly it would be transformed into the type of laminated Brown or Black Lignite which is so abundantly found in the Middle Western States of North America (North and South Dakota, Wyoming) and in the province of Saskatchewan, in Canada.

In the course of further "maturing" the lignite would acquire a shiny black colour and a well-marked conchoidal fracture; eventually it would pass into a class which is sometimes termed "*Sub-Bituminous*," to indicate its intermediate character between the true lignites and the older bituminous coals. Such types are found both in the United States and in the province of Alberta, in Canada; and they are chiefly cretaceous in origin. We thus arrive at the following provisional representation of the wood-coal series.

THE WOOD TO COAL SERIES.*

0.. WOODY TISSUE (Lignocelluloses)

↓

1. .. PEAT (Quaternary) { Water = 90; Combustible = 10.

↓

2.. EARTHY BROWN COALS (Tertiary) { Water = 40 to 50; Coal = 50 to 60 } — WOODY BROWN COALS. (Tertiary)

↓

3.. LAMINATED LIGNITES (Chiefly Tertiary) { Water = 20 to 40; Coal = 60 to 80

↓

4.. SUB-BITUMINOUS COALS (Chiefly Cretaceous) { Water = 10 to 20; Coal = 80 to 90

↓

5.. BITUMINOUS COALS (Mesozoic Carboniferous) { Water < 10; Coal > 90

↓

6.. SEMI-BITUMINOUS COALS (Carboniferous)

? ↓ ?

7.. ANTHRACITIC COALS (Carboniferous)

* The author wishes it to be understood that this classification is meant to be provisional only and subject to modification as further knowledge of the subject is gained.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

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Coals may be conveniently divided into five principal genera, namely (A) Brown Coals and Lignites, (B) Sub-Bituminous, (C) Bituminous, (D) Semi-bituminous, and (E) Anthracitic, of which the two first are generally speaking, of more recent origin than the other three. They may all be considered as representing some stage or product of the primary decomposition and subsequent transformation of the vegetable debris of primeval forests and swamps. The process has gone on since carboniferous times in most of the great geological epochs; and, so far as its earlier stages are concerned, it is being repeated in our peat bogs and deltas, where water-logged vegetable debris is decomposing under bacterial influence.

Whilst it is not my object in this paper to discuss the origin and mode of formation of brown coals and lignites, about which there is some difference of opinion, yet a passing reference to the matter will perhaps assist us in judging of their character and value in relation to other coals. From a chemical standpoint, I can see no adequate reason for rejecting the orthodox view that they are intermediate forms between peats and bituminous coals, although our present ignorance of the subject imposes upon us the duty of expressing it guardedly as a provisional hypothesis.

The original vegetable debris from which all coals have been formed, must have consisted for the most part of ligno-celluloses *plus* a certain proportion (probably not exceeding 10 to 20 per cent.) of vegetable proteids. According to Cross and Bevan, ligno-celluloses may be regarded as built up primarily of (1) a lignone portion, consisting of a reactive "keto R - hexene group" and a "furfurose" (*i.e.*, furfural-yielding) complex, combined with (2) α and β cellulose groups, one of which is chemically more resistant than the other. Schultze and Schuppe regard wood tissue as an aggregate of five cyclic cellulose groups ($C_6H_{10}O_5$) and a lignone complex ($C_{19}H_{18}O_8$), the ultimate composition of which would be approximately:—
$C = 50.0$, $H = 5.75$, and $O = 44.25$ per cent. The debris would also probably contain, besides the foregoing main components, a certain small amount of resins, and it would be mingled with more or less mineral matter.

We must picture then vast masses of such water-logged material, first of all, decaying, either upon the actual site of its original growth (as in a peat bog), or after being macerated into a pulp and transported and deposited by water in some other low-lying swampy area. In this (which may be called the peat-bog stage) it would be subjected to the decomposing actions, both of aërobic fungi and anaërobic organisms, whose relative influences would depend upon the varying water level in the bog; with the result that the larger proportion of it would be resolved into gases (methane and carbon dioxide) and water vapour, leaving an amorphous or gelatinous humic residue comprising the more stable and resistant parts of the original debris *plus* a large amount of water. Some portion of the residue would probably be reduced to a condition of colloidal solution (*i.e.* of a *gel*), whilst the more complex and resistant part would be in a condition of ordinary admixture with, or suspension in, water. Indeed, raw peat in a well-drained bog contains as much as 90 parts of water to 10 parts of the peat substance.

In course of time, this rotted debris would either be overlaid *in situ* (during a subsequent period of subsidence), with layers of water-deposited sands or clays, or be transported by water and deposited in some other lower-lying locality, where it would be similarly overlaid with mineral matter. In either case, under the influence of a slowly increasing pressure, its water-content would gradually diminish, with the result that its combustible matter would be gradually consolidated. Under

such conditions it would be slowly transformed into something resembling the most recent types of amorphous and non-laminated "brown coals," which are of tertiary origin, and usually lie not far below the surface. They still contain a large proportion of water, in some cases as much as 50 per cent.; they are termed Earthy Brown Coals, and are quite devoid of any organic structure. As typical examples may be mentioned (*a*) the Morwell brown-coal deposits in Australia, about which more later on, and (*b*) the German brown coals, which occur in beds of either miocene or oligocene age in Saxony, Brandenberg, and in the Rhine Provinces.

Besides such "amorphous" brown coals, and probably of similar recent formation, there are occasionally found varieties which have a very woody appearance and fibrous structure. As a good example of this class may be instanced the Valdarno deposits which occur in lower Pliocene measures in a mountain chain separating the valley of the Arno from that of Chianti in Northern Italy. Their "woody" character is so marked that they can often be sawn into pieces without crumbling. They have a chocolate brown colour, and in the raw state contain between 40 and 50 per cent. of water. Their outward appearance suggests that they have been formed from wood which, instead of having passed through the usual "peat bog" stage, has undergone a less drastic decay, not involving the disappearance of their woody character. Such fibrous brown coals are a distinct class by themselves, and may perhaps have been formed under somewhat different conditions to other varieties.

In cases where the incipient earthy "brown-coal" deposits became in course of time, buried more and more deeply under accumulations of newer mineral strata, a "blanketting" effect would be produced, with consequent gradual increase in both temperature and pressure. A similar effect would also be produced by earth-movements. This would presumably cause a partial desiccation of the coal, accompanied by certain chemical changes, affecting principally its cellulosic constituents, and resulting in a diminution of the oxygen and an increase in the carbon content of the "coal substance" itself. The deposit would thus become gradually more consolidated; in process of time it might acquire a laminated structure; and with increasing carbon content its colour would darken. Slowly it would be transformed into the type of laminated Brown or Black Lignite which is so abundantly found in the Middle Western States of North America (North and South Dakota, Wyoming) and in the province of Saskatchewan, in Canada.

In the course of further "maturing" the lignite would acquire a shiny black colour and a well-marked conchoidal fracture; eventually it would pass into a class which is sometimes termed "*Sub-Bituminous*," to indicate its intermediate character between the true lignites and the older bituminous coals. Such types are found both in the United States and in the province of Alberta, in Canada; and they are chiefly cretaceous in origin. We thus arrive at the following provisional representation of the wood-coal series.

THE WOOD TO COAL SERIES.*

0.. WOODY TISSUE (Lignocelluloses)

↓

1. .. PEAT (Quaternary) — Water = 90; Combustible = 10.

↓

2.. EARTHY BROWN COALS (Tertiary) — Water = 40 to 50; Coal = 50 to 60 — WOODY BROWN COALS. (Tertiary)

↓

3.. LAMINATED LIGNITES (Chiefly Tertiary) — Water = 20 to 40; Coal = 60 to 80

↓

4.. SUB-BITUMINOUS COALS (Chiefly Cretaceous) — Water = 10 to 20; Coal = 80 to 90

↓

5.. BITUMINOUS COALS (Mesozoic Carboniferous) — Water $<$ 10; Coal $>$ 90

↓

6.. SEMI-BITUMINOUS COALS (Carboniferous)

? ↓ ?

7.. ANTHRACITIC COALS (Carboniferous)

* The author wishes it to be understood that this classification is meant to be provisional only and subject to modification as further knowledge of the subject is gained.

Some Characteristic Properties of Brown Coals and Lignites.

Brown coals and lignites are characterised by the following properties, which, taken together, differentiate them completely from the geologically older bituminous coals, namely in that:—(i) in the raw state they contain a large amount of water (*e.g.* generally more than 20 and sometimes even as much as 50 per cent.); (ii) on losing the same by "air drying" they usually disintegrate, either crumbling to powder or developing well-marked laminar cracks; (iii) they are devoid of coking properties; (iv) in the "dry-ashless" state they usually contain less than 75 per cent. of carbon and more than 20 per cent of oxygen; and (v) on carbonisation at 900° they yield upwards of 45 per cent. of "volatiles." The following table shews the ultimate compositions of representative examples of the various stages in the peat-coal series:-

fact that, owing to their low carbon and high oxygen contents, they have (even when completely dried) much lower calorific values, and yield on carbonisation much higher proportions of "volatiles" than bituminous coals, makes it extraordinarily difficult to utilise them in the raw state with reasonable efficiency for steam raising purposes in boilers. For so much heat is required to vaporise their natural water-content, that they do not give a sufficiently hot and radiating fire to ensure rapid heat transmission in boilers; also, their high "volatile" yield means that they burn with a long and smoky flame, which is not conducive to efficient working. Moreover, bad as is the natural high water content of raw lignites from a steam raising point of view, it is still worse from that of carbonising them for gas making under by-product recovery conditions. It hardly needs an experienced gas engineer to shew the

TABLE I.

Analyses of Typical Peats, Brown Coals, Lignites, Sub-Bituminous and Bituminous Coals.

		Irish Peat	Brown Coals. Italian Valdarno	Brown Coals. Australian Morwell	Brown Lignite Saskatchewan	Black Lignite Malayan	Sub-Bituminous Nigerian	Bituminous Barnsley Hard Steam
% Water in the Raw Fuel		90	40 to 50	50	30 to 40	20	10	2.5
% Ash in the Dry Fuel		4.5	5 to 10	4.0	6 to 12	6 to 10	7.5	2.75
Referred to the Dry Ashless Coal Substance.		%	%	%	%	%	%	%
	Carbon	60.2	60.30	65.10	69.25	73.0	75.0	84.70
	Hydrogen	5.5	5.40	5.00	4.75	5.5	6.0	5.10
	N and S	2.0	1.95	0.45	1.70	1.5	2.4	2.25
	Oxygen	32.3	32.35	29.45	24.30	20.0	16.6	7.95
	% Volatiles at 900° C.	65	57.8	57.6	48.0	46.5	45	33.0
	(Gross Calorific) value K.C.Us. per Kg.	5600	5800	5830	6330	6900	7625	8280

Their Low Grade Characters in the Raw State.

It will readily be understood how formidable are the difficulties encountered in utilising such low grade fuels. In the first place, their naturally high water contents, together with their tendency to disintegrate on being dried by any ordinary method, precludes their transportation in the raw state for any long distance. Next, the impracticability of carbonising, either in retorts or chambers, a coal containing anything from 20 to 50 per cent. of water, or to foresee the difficulties that would be encountered in attempting to recover tars and light oils from the steam-laden gas that would issue from the retorts. It may, therefore, be taken for granted that any scheme for carbonising such coals on a large scale ought at least,

to include some preliminary drying process.

Against such disadvantages must, however, be set the following compensating circumstances, namely, (i) that lignite and brown coal deposits usually lie so much nearer the surface, and are often of so much greater thickness, than those of the older bituminous coals, that the cost of mining them is, comparatively speaking, very small; (ii) that some lignites are capable of yielding, on carbonisation at low temperatures, a variety of valuable by-products comprising condensable hydrocarbons, fuel and lubricating oils, solid paraffins, etc., as well as a smokeless "fuel-residue" which can be briquetted; and (iii) that, if subjected to a suitable heat treatment (to be specified later) they may be transformed into much more efficient steam raising and gas-making fuels than might be supposed from their natural low grade characters.

How much the mere drying of a brown coal will increase its "effective" calorific power for steam raising purposes in boilers will be apparent from a consideration of the following figures relating to the Morwell Brown Coal from Australia, which in the raw state contains about 50 per cent. of water. A given weight of raw coal would, therefore, be composed half of water and half of the dry coal. Now the *gross* heat of combustion of 0.50 Kg. of dry fuel would be 2,800 K.C.Us.; part of this heat, however, must necessarily be expended in vaporising the 0.50 Kg. of associated water, and another part would be rendered ineffective on account of the 0.225 Kg. of steam which is formed when the fuel is burnt. These two items would amount altogether, to 445 K.C.Us., leaving only 2,355 K.C Us. as the "effective" calorific power available for transmission to the water in the boiler. Thus it would appear that, taking into account the latent heats of the water present in the raw fuel and of that formed on its combustion, no more than 84 per cent. of its gross calorific value could possibly be "effective" in the boiler. And as, in the best of circumstances, no more than about 70 per cent. of such "effectively available" heat would actually be transmitted to the water in the boiler, and, therefore, finally appear as "available steam energy," it follows that no greater boiler efficiency than about 60 per cent. would be likely to be achieved by using the *raw* coal, and it would probably be considerably less.

In this connection, it may be mentioned that in carefully measured steam trials carried out in a hand-fired Heine water-tube boiler, fitted with a Stilwell-Pierce feed-water heater, at the St. Louis Exposition, in October, 1904, by the technical staff of the U.S. Geological Survey, the efficiencies obtained using (*a*) Texas lignite briquettes containing 23.27 per cent. of water and 15.87 per cent. of ash and (*b*) N. Dakota lignite containing 38.85 per cent. of water and 10.63 per cent. of ash, did not exceed 42 and 50 per cent. respectively.*

The beneficial effects which might be expected to accrue from some preliminary drying (whether partial or complete) of such a raw fuel as Morwell Brown Coal are shewn by the following figures :—

Composition of 1 Kg. Fuel charged into Boiler. Water Kg.	Dry Coal Kg.	Gross Cal. value of Fuel as charged K.C.Us. per Kg. H_1.	K.C.Us. available for Heat Transmission per Kg. Fuel charged. H_2	Resulting Available Steam Energy assuming a 70% Transmission Efficiency. H_3	Ratio $H_3 \cdot H_1$
0.50	0.50	2800	2355	1650	0.589
0.30	0.70	3920	3542	2480	0.633
0.10	0.90	5040	4730	3310	0.657
nil.	1.00	5600	5324	3725	0.665

GEOGRAPHICAL DISTRIBUTION.

Before, however, considering further their economic utilisation, it will be convenient now to refer to the geographical distribution of brown coals and lignites, and to their importance to some parts of the Empire.

Although it would be untrue to say that the geological age of a coal necessarily determines its type and properties, yet it is nevertheless usually found that up to the "bituminous" stage the older the coal (*ceteris paribus*) the more mature is it likely to be. Thus most of the brown coals and

*U.S Geological Survey Professional Paper No. 48, Part II, Washington, 1906.

lignites are geologically of tertiary age, whilst those which I have provisionally designated "sub-bituminous" are usually cretaceous.

The tertiary brown or lignitic coals occur chiefly (i) in what may be termed the Pacific borderlands (*i.e.*, in America west of the Rockies, Japan, Australia, New Zealand, and the E. Indies) ; (ii) in regions adjacent to, or in continuation with, the Gulf of Mexico (*i.e.* Texas, Mississippi, Arkansas, Alabama); and (iii) in regions north of the Mediterranean, including the Central European Plain. There is also (v) a large area in the United States and Canada (comprising N. and S. Dakota, Montana, Wyoming, Saskatchewan, and Alberta) in which coal-forming conditions prevailed during the cretaceous period, and were continued in great luxuriance into the subsequent tertiary period. In this area there are now immense reserves both of "sub-bituminous" coals and lignites in the upper cretaceous and in the later tertiary formations. The "sub-bituminous" coals in this area are usually in the upper cretaceous formation.

THE BROWN COAL INDUSTRIES OF CENTRAL EUROPE.

In pre-war days the only countries which had systematically worked their brown or lignitic coal resources on any important scale were Germany and Austria-Hungary, in both of which a considerable brown-coal technology had been developed. In order to show the important dimensions to which the brown coal industry of Central Europe had attained before the War, it needs only to be stated that the German output (gross) of brown coals had increased from about 31.6 million tons per annum in 1898, to the astonishingly high figure of 87.1 million tons in 1913 (or, in other words, had almost trebled in 15 years); also, that for the year 1913 the Austrian production amounted to 27.4 million tons, and that of Hungary to about 8 million tons. Indeed, during the decade immediately preceding the War (*i.e.*, 1904-13 inclusive), the brown coal output in those regions had expanded in an even greater ratio than that of black coal, a remarkable testimony to the enterprise of our late enemies in matters pertaining to the economic development of their countries' mineral resources.

The principal brown coal mining areas in Germany are :—(1) in Saxony and Brandenberg, where the beds are of Miocene age ; (2) in the Province of Hesse, and (3) in the Rhine Province (Cologne, Bruhl, and Bonn districts) where the beds are chiefly of Oligocene age.

In the Cologne District, which may be taken as a typical example, the main deposit occurs in a large tertiary (Oligocene) bed, comprising white sands, plastic clays, and brown coals, capped by diluvial deposits. It is bounded on the S.W. by the Eifel chalk and on the N.E. by what are described as Devonian formations (shales). These tertiary beds attain a maximum thickness of 300 metres (say nearly 1,000 ft.). There are two layers of brown coal, the lower one extending over the whole area, but the upper one (which is chiefly worked) covers only a small part. The thickness of the upper coal, which is so near the surface that it can be won at a very low cost, varies between 20 metres in the South to as much as 100 metres in the North (average thickness about 27m.)

The raw coal contains nearly 50 per cent. of water. After being quarried it is subjected to a drying process in a revolving steel cylinder, about 22ft. long and 7ft. 3in. in diameter, inclined at an angle of 6° to the horizon, which is internally heated by exhaust steam passed through a series of tubes. Its moisture content having thus been reduced to about 15 per cent., the coal passes on to the briquetting factory, where it is pressed into briquettes of various sizes for domestic and industrial consumption. The calorific value of such briquettes is said to be about 4,800 K.C.Us. per Kg. (8,640 B.Th.Us. per lb.); and although this may seem small compared with that of a good black coal, yet, owing to their low cost of production (which in pre-war days probably did not exceed 10 marks per ton) there is no difficulty in disposing of them profitably for domestic and industrial purposes. German engineers had successfully designed boilers fitted with special types of grates for burning such brown coal briquettes, with "efficiencies" which (it was claimed) sometimes reached as high as 65 per cent. They had also developed a considerable distillation industry whereby, from the resulting crude tars, they obtained valuable burning oils and paraffin, besides a solid fuel residue.

The Austrian brown coal beds principally occur (i) in N.W. Bohemia, near the Erzegebirge borderland between Bohemia

and Saxony, where the tertiary formation runs in a direction S.W. by N.E. from the entrance of the Eger to the Elbe, a distance of 160 kilometres, and attaining in places a width of 25 to 30 kilometres, and (ii) in a broad belt of country extending on either side of a line drawn between Vienna and Trieste, and passing through the provinces of Styria, Carinthia, and Carniola.

The Bohemian lignites, which chiefly lie within 500ft. of the surface, were in pre-war days worked at a low cost by shallow shafts. In the raw state they were said to contain about 25 to 30 per cent. of water, and to be of a superior quality as such fuels go. At any rate, they were capable of supporting considerable chemical, textile and engineering industries in N.W. Bohemia. About half of the Austrian output was exported chiefly to Germany, Switzerland, and Hungary.

Time does not permit of my discussing the production of brown coal in Hungary and North Italy; but sufficient has been said to indicate how successfully the Central European peoples had developed their brown coal industries.

The Lignite Question in the United States.

Although it is estimated that about one-third of her immense potential coal resources are lignites, it was not until the United States entered the war that she began to pay serious attention to the problem of effectively utilising them. They chiefly occur in Texas and Alabama where the beds are of tertiary origin, and in N. and S. Dakota, Montana and Wyoming, where they are chiefly cretaceous.

In the year 1918 the U.S. Bureau of Mines issued a bulletin (Technical Paper 178) setting forth the importance of scientifically developing the principal lignite fields, and pointing out that into the N. Dakota section alone, there were being imported annually from the eastern coalfields no less than 2 million tons of bituminous coals and 1 million tons of anthracites, every pound of which ought some day to be replaced by the local lignites. It was estimated that to do this would require the carbonising of about 6 million tons of lignites annually, which would yield 3 million tons of a carbonised solid fuel, 60 million gallons of tar distillates, 45,000 tons of ammonium sulphate, besides 18,000 million cub. ft. of surplus gas.

It was also suggested that in Texas, where are large iron ore deposits, with limestone near at hand, which up to then could not be smelted because of the high cost of delivering Alabama coke at the furnaces, the production of a carbonised lignite briquette at a cost not exceeding half that of Alabama coke would entirely alter the situation.

Among the specific proposals already put forward by the U.S. Bureau of Mines for the better utilisation of these lignite resources may be mentioned (i) the drying of the raw coals before use, (ii) the employment of the dried fuel in pulverised form for use in cement kilns, steam raising, and furnace operations generally, (iii) the manufacture of dried lignite briquettes for burning under boilers, and (iv) the manufacture of carbonised lignite briquettes for use in suction-gas producers and as a domestic fuel.

Importance of Lignites to the British Empire.

Turning now to the great Federation of Commonwealths known as the British Empire, it may at once be said that, whilst Great Britain itself is almost destitute of lignites (the well-known Bovey Tracey deposit in Devonshire being the only important one), the solution of the various technical difficulties associated with their efficient use is of especial importance to Canada and Australia, as well as to other parts of the Dominions.

Canada.—Of the estimated Canadian coal reserves, which amount altogether to no less than 1,234,269 million tons, no less than 1,072,627 million tons are of a "sub-bituminous" lignitic class, and occur in the upper cretaceous formation of the province of Alberta.

In the neighbouring province of Saskatchewan, there are two coal-bearing formations, the higher one being of tertiary age, which is comparable with the Fort Union group of N. Dakota, whilst the lower one is cretaceous. The tertiary beds are now being mined, especially in the Souris Valley, and in many places the individual seams run from 8 feet to 16 feet in thickness, and are mostly within 250 feet of the surface. The Saskatchewan reserves alone are estimated to amount to 59,812 million tons; and an investigation recently made in my laboratories upon four representative samples from the Souris Valley showed them to be of a laminated lignite class, containing

in the raw state between 30 to 40 per cent. of water, which, however, can be reduced to about 18 per cent. by "air-drying." The completely dried coals contained :—

	Per cent.	
Carbon	61.6 to 64.5	Gross calorific values 5650 to 5980 K.C. Us. per kilogram
Hydrogen	4.2 to 4.7	
Sulphur	0.6 to 0.9	
Nitrogen	0.6 to 1.0	
Oxygen	20.5 to 24.7	
Ash	6.1 to 11.2	

The Dominion Government has set up a Lignite Utilisation Research Board provided with funds to carry out researches and investigations upon such lignites, and it was through this Board's courtesy that I received the samples referred to. There can be no doubt as to the vital importance to the whole of Western Canada of a well-organised scheme of exploiting scientifically these immense tertiary and cretaceous coal resources of Alberta and Saskatchewan.

AUSTRALIA.—Extensive deposits of tertiary brown coals occur in the province of Victoria, particularly in the Gippsland and Cape Otway districts. Of these, the celebrated Morwell deposits are of phenomenal thickness, without parallel elsewhere in the world. Morwell itself lies in (or near) the Latrobe Valley, where extensive faulting took place towards the close of the Miocene period, producing enormous depressions in which large accumulations of vegetable matter were deposited evidently during Pliocence times. These originated the present brown coals of that locality. It has been estimated that within an area of 50 miles square in the Latrobe Valley, and within 1,000 feet of the surface, there are 31,144 million tons of the coal. A bore-hole put down near Morwell, disclosed no fewer than seven beds of brown coal within 1,000 feet of the surface, of a total thickness of 781 feet, the individual seams (taken in order from the surface) running 29ft. 8ins., 25ft. 8ins., 23ft., 227ft. 10ins., 265ft. 6ins., 166 ft., and 43ft. 8ins. respectively—a perfectly wonderful store of energy awaiting the service of man. So far as they have been examined, they were reported by the Victorian Advisory Committee on Brown Coal, in 1917, as consisting of "a matrix of earthy brown coal, with sporadic inclusions of lignite. . . . the matrix consists of pollen grains, spore cases, and decomposed vegetable matter . . . . The coal varies in colour between yellowish brown and black, but it always pulverises to brown powder."

The raw coal usually contains about 50 per cent. of water. During the course of some investigations carried out under my direction upon a representative consignment of it in the Fuel Laboratories of the Imperial College, South Kensington, it was found that the *dry* coal contains :—Carbon= 62.5, Hydrogen=4.85, Nitrogen=0.45, Sulphur=0.20, Oxygen=28.00, and Ash= 4.00 per cent. Its gross calorific value was 5,600 K.C.Us. per kilogram.

In the year 1917 the Advisory Committee appointed by the Victorian Government to investigate the possibilities of generating electric power on a large scale from the Morwell coal reported that, notwithstanding its low grade, power could be more cheaply generated from it for the city of Melbourne than from black coal imported from New South Wales. It was officially estimated that, about that time, the cost of producing raw Morwell coal at the mines would not exceed 2s. 9d. per ton, and that it could be delivered by the existing railway in Melbourne (97 miles distant) at 7s. 8d. per ton against about 20s. for black coal from New South Wales.

According to my latest information, things are now moving rapidly on the lines indicated in the Committee's report. Large scale steam trials are in progress, with a view to ascertaining how the coal may best be burnt under boilers; a big electric power station scheme at Morwell is now materialising, with every prospect of success, and a large order for water-tube boilers in connection therewith was recently placed in this country. As the result of all these developments, it is anticipated that, in a few years hence, not only will the city of Melbourne derive the whole of its electric power from Morwell coal, but that the Victorian State railways will also be worked electrically by energy generated from the same deposits.

NEW ZEALAND.—According to the report upon the World's Coal Resources, issued by the International Geological Congress in the year 1913, New Zealand's available coal reserves are estimated at 3,386 million metric tons, of which no less than 2,080 million tons (or about 60 per cent.) are brown coals and lignites. The chief coal-bearing rocks are said to be of tertiary age, but it is thought that coal will almost certainly occur in the upper cretaceous

formations. The lignite question is, therefore, a very important one for New Zealanders, and already a start has been made with its scientific investigation. I am indebted to an official bulletin issued in 1918 by the New Zealand Board of Science and Art for the detailed results of some gas-producer and low-temperature distillation trials carried out on the native brown coals by some of its National Research Scholars. Up to then the work, although excellently begun, seems to have been rather of a preliminary character; but it will, doubtless, be duly pressed forward to completion.

INDIA.—Through the kindness of Mr. Cyril S. Fox, of the Geological Survey in India, who is now in this country, I am able to give the following particulars concerning the occurrence of lignites in that country. Mr. Fox has written as follows: —

"Beds and lenticular patches of lignite "occur in association with cretaceous and "tertiary strata in various parts of India. "(i) Lenticular patches have been found "in Ross and Viper Islands at Port Blair "in the Andamans. (ii) In the Dirjum "Gorge at the foot of the Abor hills and "between Pasighat and Janak-Mukh in "Assam. (iii) Deposits have been reported "and examined along the foot hills of the "Himalaya in the Darjeeling District and "near Baxa and Jainti in the Jalpaiguri "District of Bengal. (iv) The lignite of "Ratnagiri in the Bombay Presidency has "been known for some time. (v) Occur-"rences have been recorded from Burma, "near Kindat, in Chindwin (Upper); near "Talang in the Kachin hills of Myitkyina; "in the neighbourhood of Kyeintali in the "Arakan Hill Tracts of Sandaway; and "near Hsikip and about Nangon in the "South Shan States. (vi) Deposits occur "in the Raipur District of the Central "Provinces at Bhatagaon, Chugwa and "Jumrao. (vii) The occurrences in Canna-"nore, Bepur and Warkalli of Malabar in "the Madras Presidency are important. "It is estimated that 276 million tons of "lignite are available in the coastal tract "of Travancore. (viii) Two deposits, near "Katmandu and Etaunda, occur in Nepal. "(ix) Extensive beds of lignite were en-"countered in boring operations in the "coastal tracts between Pondicherry and "Cuddalore at Bahour, Aranganur and "Koniakovil. The depths at which these "beds, varying from 25 to 50 feet thick, occur "were 275 feet, 203 feet, and 330 feet re-"spectively. An average sample analysed "by Mallett gave: Carbon, 25.2%, Volatile "matter, 29.1%; Water, 35.3% and Ash "10.4%. (x) The jet coal of Kalabagh in "the Mianwali District and the exposures "in Nerh Hill, near Murree, in the Rawal-"pindi District are the reported discoveries "of the Punjab. (xi) Lignite occurs in "several places, *i.e.*, near Kalka, Siliani, "Kalawala, Kotdwara, etc., along the "Siwalik foot-hills of the United Provinces.

"The lignite beds of the Malabar Coast, "particularly in the Travancore country, "do not appear to have received the serious "attention they deserve. The matter is "the more urgent when it is appreciated "that 90% of the coal production of India "is obtained from the so-called Bengal "Coalfields of Raniganj, Jherria and "Giridih, and that the railway transporta-"tion facilities from this region are ad-"mittedly inadequate. It is only too well "known that any dislocation of the coal "traffic from this area, either as a result "of labour trouble or other causes, seriously "affects the various industries which depend "on the supply of coal from the above "fields. The recent establishment of great "steel and iron works and the projected "erection of similar larger plants in the "neighbourhood of the Bengal coalfields "must lead to strict economies in the "utilisation of the valuable coking coals "of these fields. It would, therefore, "seem that the time has come for a con-"sideration of the decentralization of the "coal supply of India. By the development "of other fuel resources of the country, "it is possible that cheaper fuel may be "obtainable in certain more distant in-"dustrial areas now dependent on Bengal "coal. It is also likely that a stimulus "will be given to the local commercial "activity of those tracts which have peculiar "industrial potentialities."

BURMA AND THE MALAY PENINSULA.—Important deposits of well-matured lignites have been found in both these countries; but our knowledge of their resources of such coals is as yet very imperfect.

At Rawang (Malaya) a coal area has been opened out, and is being developed by the Malayan Collieries Company, Ltd. The coal-bearing series in that neighbourhood are said to consist of shales and sandstones resting on a foundation of quartzite and slates, and are thought to be of tertiary age. There are two seams, the upper of

which exceeds 24, and may possibly attain to 50 feet in thickness. Extended trials of this coal have been made with the object of testing how best it may be utilised for various purposes, such, for example, as steam raising and power-gas production. Also large-scale low temperature distillation trials have been carried out, with most interesting results, both as regards the character of the various oils and other by-products obtainable, and the manufacture of a briquetted smokeless steam-raising fuel from the carbonised residue.

The raw coal is a well-matured brown-black laminated lignite, in some respects almost "sub-bituminous" in type, containing about 20 per cent. of water. The completely dried coal contains :—

Carbon = 67.9 ; Hydrogen = 4.7 ;
Nitrogen = 1.0 ; Sulphur = 0.4 ;
Oxygen = 19.6 ; and Ash = 6.0 per cent.

Its gross calorific value (dry) is about 6,100 K.C.Us. per kilogram, or, say 11,000 B.Th.Us. per lb. ; and when carbonised at 900°C., it yields about 43.75 per cent. of "volatiles."

Some General Observations upon the Utilisation of Brown Coals and Lignites.

For some years past I have been investigating brown coals and lignites, chiefly from a chemical standpoint, with a view to extending our knowledge of their behaviour on carbonisation at various temperatures, and of the character and amounts of the various by-products obtainable from them, and to finding out possible ways of overcoming some of their obvious drawbacks as gas producers and steam raising fuels. Some attention has also been paid to the technical possibilities of manufacturing smokeless domestic and steam fuels, as well as cokes suitable for metallurgical purposes, from the carbonaceous residue left in the retorts after carbonisation. A mass of useful data has thus been accumulated, which I hope may some day be collected in a handy form for publication ; but I fear it is impossible to compress them within the limits of the present paper. I must, therefore, content myself with a few general observations on the foregoing points, after which I propose to deal in detail with the practical outcome of some new experiments made with a view to enhancing the fuel-values of brown coals and lignites for steam raising purposes.

From what has already been said in the earlier section of this paper, I regard a preliminary drying operation as always very desirable, if not essential, to the economical utilisation of such fuels, either for steam raising or carbonisation purposes. Prolonged "air-drying" is usually capable of reducing the water content of the raw fuel down to about 15 per cent. ; but such a process is too dependent upon climatic conditions, and, moreover, takes too much time, to be generally practicable on a large scale. Consequently, other means must generally be resorted to, and it is obvious that they should, whenever possible, involve the utilisation of some convenient form of "waste-heat," such as either exhaust steam or the products of combustion from boiler furnaces, retort settings, or the like.

It can easily be shewn by calculation, that if a *dried* lignite be burnt under boilers, there is vastly more available heat in the gases leaving the boiler at, say, a temperature of 400° C., than would be required to completely dry the raw fuel, even if it contained as much as 50 per cent. of water. But, owing to the readiness with which dry lignites ignite, as well as to the tendency of the raw fuels to disintegrate on being dried, the problem of successfully applying the "hot chimney gases" is not without its difficulties. Our experiments have, however, shewn that such gases can generally be employed safely for the purpose, provided that they contain more than 10 per cent. of carbon dioxide, which condition should not be difficult of regular attainment on large boiler installations where the scientific control of combustion is carried out.

Provided, then, that the brown coal or lignite has been previously dried, the problem of carbonising it at any particular temperature will usually be of no greater complexity than it would be in the case of a rather low grade non-coking bituminous coal, always allowing for the circumstances that brown coals and lignites are devoid of coking properties, and that their carbonised "residues" ignite more readily than would coke if allowed, whilst hot from the retort, to come into contact with air. Their residues may, however, be briquetted with suitable binding, making excellent domestic and steam raising fuels.

Compared with those usually obtained from bituminous coals, the gas-weight and liquor

yields (referred to the *dry* coal) are generally higher, although the gas contains an unusually large percentage of carbon dioxide, owing to the higher oxygen content of the coals. The gas would certainly have to undergo some "lime" purification process for the elimination of its carbon dioxide before it would be suitable for public distribution; and even then its content of carbon monoxide would be higher than I should like to see, although my good friends in the gas industry would probably view the same with equanimity, if not with positive delight.

The question of the low temperature carbonisation of lignites is receiving attention in many quarters and is worthy of much further study. Some lignites that I have investigated yield most valuable fuel and light oils, but time does not permit of my particularising.

There is also no particular difficulty about gasifying lignites in producers, and with good results as far as the quality of gas is concerned. As an example I may here quote the results of trials carried out by the Power Gas Corporation Ltd., upon French and Italian lignites in a Mond By-Product Peat Gas Producer Plant at Orentano:—

	French Lignite (from La Savoie).	Italian Lignite (Ribollo).
	%	%
Moisture in Coal charged	40.5	8.5
The Dry Fuel contained:		
Fixed Carbon ..	33.9	—
Volatiles	50.1	—
Ash	17.7	16.2
Nitrogen	1.8	1.9
Yield of Gas:		
Cub. Ft. at 15° C. per ton Dry Fuel	78,300	71,700
	%	%
Composition of the Gas:		
CO_2	20.8	16.3
CO	10.6	11.5
H_2	25.6	26.3
CH_4	5.4	4.8
N_2	37.6	41.1
	100.0	100.0
Yield of Ammonium Sulphate in lbs. per ton of Dry Coal ..	92.5	130

In measured gas producer trials conducted under my personal supervision upon Malayan and other lignites quite as good results as the foregoing have been obtained, but they are not available for publication.

Heat Treatment at Temperatures Below 400° C. as a Possible Method of Enhancing their Fuel Values.

In the course of my researches upon brown coals and lignites, I had occasion to study their behaviour when, after being previously completely dried at 110° C., they were further heated, out of contact with air, in a special form of apparatus which permitted both an easy control of the temperature condition, and the accurate measurement of any liquid or gaseous products that might be evolved.

In my first experiments on such lines, which were made upon the Morwell brown coal already referred to, some highly significant observations were made, which subsequent research has proved to be characteristic of brown coals and lignites generally. The detailed results of these researches having already been published about a year ago in the proceedings of the Royal Society, A. Vol. 99 (1921), I need now describe them in outline only, with some additional information concerning the practical developments which have since flowed therefrom.

It was found with the dried Morwell coal that, beginning at as low a temperature as 130° C., but principally between 250° and 375° C., a chemical condensation occurred, affecting the cellulosic or humic constituents thereof, which was characterised by the simultaneous elimination of both steam and carbon dioxide from the coal substance itself, without any appearance of oils or more than a quite negligible amount of gaseous hydrocarbons. Thus, in a typical experiment, when the temperature of 100 parts by weight of the dried coal was slowly raised to, and then maintained at 375° C., until no further change occurred, there were eliminated 5.5 parts of water and 6.6 parts by weight of gas (= 1427 cub. ft. per ton of the dry coal), which latter contained:—

$H_2S = 1.5$, $CO_2 = 88.5$, $CO = 4.1$, $CH_4 = 1.1$ and $N_2 = 4.8$ per cent.

It was thus clear that the said heat treatment had brought about a chemical condensation in the coal substance itself, possibly comparable with that by which, deep down

in the bowels of the earth, our present bituminous coals, in the course of long ages, have been slowly produced from pre-existing brown coals. Such condensations had involved a marked elimination of oxygen (as both steam and carbon dioxide) from the coal substance, with consequent considerable weight loss (amounting to one-eighth of the original) and marked increases both in the percentage of carbon content and calorific value.

The percentage composition and calorific value of the dry coal treated, and of the "residual coal" obtained were as follows :—

	Dry Coal treated.	Residual Coal.
Carbon ..	62.50	68.5
Hydrogen ..	4.85	4.9
N. and S. ..	0.65	0.8
Oxygen ..	28.00	21.2
Ash ..	4.00	4.6
	100.00	100.00
Gross Calorific Value K.C.Us. per Kg. ..	5600	6360

The chemical and thermal balances of the experiment were as follows :—

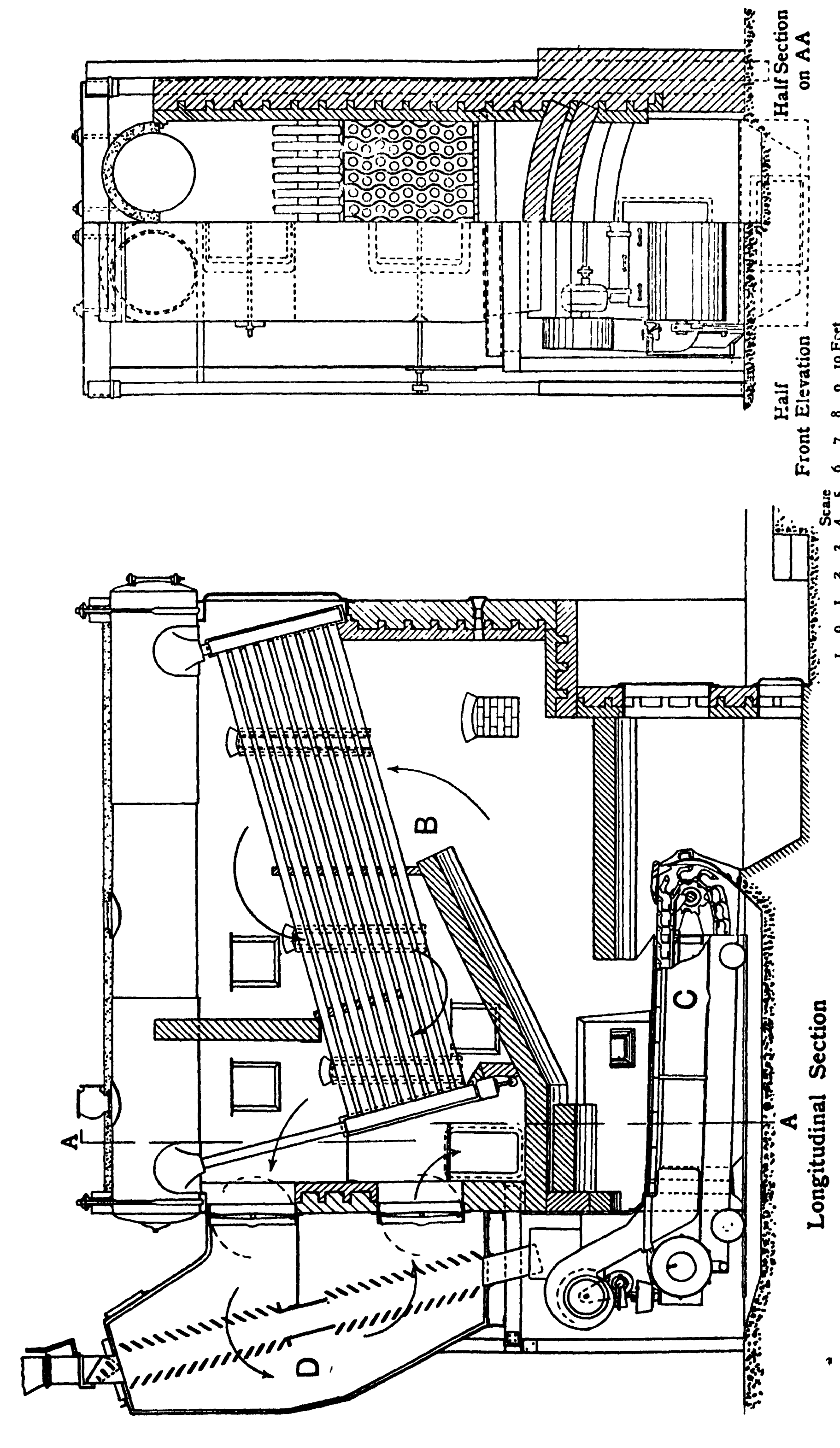
	100 Parts of the dry coal containing Parts.	yielded—>		87.6 Parts of Residual Coal containing :- Parts.
		$5.5\ H_2O$	$6.5\ CO_2$	
Carbon ..	62.50			60.00
Hydrogen ..	4.85			4.30
Oxygen ..	28.00			18.55
K.C.Us. ..	560,000			558,000

It will thus be seen that whilst the dry coal had lost about one-eighth of its original weight, it had retained practically the whole of its potential heating power, but in a more concentrated form. The weight loss had amounted to about one-third of the oxygen, one-tenth of the hydrogen, but only one-thirtieth of the carbon originally present in the coal substance—a very remarkable result.

Subsequent research showed that such behaviour on similar "heat treatment" is characteristic of brown coals and lignites as a class, and that such treatment affords a ready means of "up-grading" such coals, and of improving their fuel values generally.

At this juncture I got in touch with Mr. W. R. Wood, General Manager of the Underfeed Stoker Co., London, who had had considerable experience in burning such low grade fuels under boilers; and I put before him the idea not only of *drying*, but also at the same time of "*up-grading*" the fuel values of brown coals and lignites by further heat treatment in the aforesaid manner, in one continuous operation, using no other energy than would be comprised in the sensible heat in the burnt gases passing away from either a boiler or a retort setting. In other words, I proposed to utilise the "waste heat" of the chimney gases (assuming them to contain more than 10 per cent. of carbon dioxide and to leave the boiler at a temperature of 400° C. or more) for the purpose firstly of *drying* the raw lignite, and secondly of "*up-grading*" the dried fuel in one continuous operation, before it reaches the boiler furnace.

Mr. Wood at once saw the advantages of such a proposal, and thought it was quite a practicable one; and, at his suggestion the Underfeed Stoker Co. undertook to see what could be done to give effect to it in practice. Ultimately they designed and patented an apparatus for the purpose, capable of being attached to a water-tube boiler. For want of a better name, I will, for the present, call it the "fuel improver" attachment, because it is designed to effect the double purpose of drying and up-grading the ingoing raw fuel at the expense of part of the heat of the outgoing products of its combustion. The following diagram shows the general arrangement of a water-tube boiler with mechanical stoker fitted with one of such attachments as designed by the Underfeed Stoker Co., which has been installed by the Victorian Government Electricity Commissioners at Morwell, and is now undergoing systematic trials there under the supervision of Mr. H. R. Harper, their Chief Engineer.



General arrangement of Boiler and Mechanical Stoker with "Fuel Improver" Attachment as installed for trial by the Victoria Government Electricity Commissioners at Morwell, Australia.

The boiler B is of the Babcock Willcox type, and is fitted with a self-contained forced-draught travelling grate stoker C ; the heating surface of the boiler is 2,436 sq. ft. and the grate area is 85.7 sq. ft. The "fuel improver" attachment D is constructed of a sheet iron casing, made practically air-tight, and is fitted with two parallel series of cast-iron plates, which are sloped at an angle of about 80° with the horizontal, so as to form a chute with open sides, the plates being arranged in the form of louvers.

The raw coal is automatically fed into the top of the chute, and in slowly passing down it encounters a directed flow of the hot products of combustion from the boiler setting, whereby it is first of all dried and afterwards "up-graded" in accordance with the plan already described. In this particular installation it should be observed that the hot gases as they leave the boiler come in contact first of all with the raw incoming fuel ; in other words, the relative passages of the fuel and gases through the apparatus is not on the contra-flow principle. As originally designed, it was intended that they should be on that principle ; but it was afterwards thought better in this first trial unit to depart from it, because there would be less likelihood of the fuel becoming ignited during its passage down the chute if the gases met the raw fuel with its maximum water content at their highest temperature. It is hoped, however, that the result of these trials will shew this to be an unnecessary precaution, in which case the contra-flow principle will be adopted in future installations. The chute is capable of containing about 2.1 tons of raw fuel which at the present rate of operating takes about 45 minutes in passing through the apparatus.

One of the principal advantages which it is expected will be gained by the use of such a "fuel-improver" in connection with big power-station boiler installations, such as the one contemplated at Morwell, where a low-grade but cheap brown coal must be used, is that drying and "up-grading" the fuel, before it is burnt in the boiler grate, will give a much hotter and more radiant fire than it would otherwise do, with consequent increase in both the steam output per boiler and the thermal efficiency of the system as a whole. In other words, it is confidently anticipated that, owing to the higher furnace temperature which will certainly be realised when such a fuel-improving arrangement is employed, the rate of heat transmission throughout the boiler will be greatly improved. Indeed in submitting their scheme for the Morwell contract, the Underfeed Stoker Co. guaranteed that nine boilers fitted with their new "fuel improver" attachment would give the same steam output as twelve boilers fired with the untreated fuel, and with a greater thermal efficiency.

As the trials of the apparatus are not yet completed, it would be premature for me to attempt in this paper to pass any final judgment thereon. But judging from the results which have so far been reported to me, I am able to say that it seems probable that the anticipations of the Underfeed Stoker Company will be amply fulfilled when the final results are known. For it has already been proved that, after passing through the "fuel improver" attachment to the boiler, the fuel burns very freely and can be efficiently consumed at high rates of combustion ; also that the treatment of the fuel brings about a marked increase, both in the furnace temperatures and in the rate of heat transmission throughout the boiler.

Thus, for example :—

(1) In a trial carried out on 6th October, last, in which the *raw* fuel was burnt *without being passed through the "fuel improver" attachment*, the rate of combustion in the grate was 34.9 lbs. per hour, and the water evaporated 6,550lbs. per hour. The furnace temperature was 928° C. (1,702° Fahr.); and the products of combustion leaving the boiler at 292° C. (557.7° Fahr.) contained $CO_2 = 10.3$, $CO = 1.7$, and $O_2 = 7.4$ per cent.

(2) In a similar trial, carried out on the following day, *in which the same fuel was passed through the "fuel improver" attachment*, the rate of combustion was 94.05 lbs. per sq. ft. of grate per hour, and the water evaporated was 20,200 lbs. per hour, the furnace temperature was 1,149°C. (2,100° Fahr.); and the products of combustion leaving the boiler at 315° C. (599° Fahr.), but the "fuel improver" attachment at 92° C. (198° Fahr.) contained $CO_2 = 13.5$ $CO = 0.33$, and $O_2 = 5.6$ per cent.

The foregoing figures are quoted just as they have been reported to me, but it is to be understood that they represent the results of two quite preliminary trials only,

and that no finality is here claimed for them. I am hoping soon to receive reports of further and more exhaustive trials, until which time I shall prudently reserve any final expression of opinion.

The author desires to express his best thanks to Sir Peter McBride, late Agent-General for Victoria; the Lignite Utilisation Board of Canada; the Lignite Research Company of London; Mr. W. R. Wood and the Underfeed Stoker Company, of London; the Power Gas Corporation Limited; and other friends for their courteous help in connection with the paper. He is also indebted to his colleague, Professor W. W. Watts, F.R.S., for helpful criticisms in regard to the geological matters dealt with in the paper.

DISCUSSION.

THE CHAIRMAN (Viscount Elveden) said he wished, on behalf of all those present, to congratulate the author on his most interesting and excellent paper and also on the fact that his discovery was being tried in practice. Sometimes a discovery had to wait a long time before it was put into practical use. The problem with which Professor Bone had dealt was a pressing one, because there were vast areas of the British Empire which were a long distance away from potential energy. He did not know Australia, but he did know Canada, and he knew that when one went to the vast Dominions of the British Empire, one realised how much further things were from one another there than they were in this country. If a fuel could be used that was found in the locality where it was to be employed, it was much better than if a fuel had to be used that was many days' journey by train from that place, and, therefore, it was of the utmost importance to Great Britain, to the British Empire and possibly to the civilisation of the whole world, that the energy of the brown coals with which the author had dealt should be tapped, that these coals should be brought into proper use and made to provide a source of energy for every district where they were found.

THE HON. JOHN MCWHAE (Agent-General for Victoria), said that ten weeks previously he was at the Morwell mine, and now that those present had heard a great deal from Prof. Bone upon the technical and scientific side of the subject, he would say a few words on the practical side. The people of this country were very much interested in the Morwell mine, which would be the home in the future of many thousands of English people. Australia had a population of only 5,360,000, men, women and children, but the country was a beautiful one and the climate magnificent. Victoria was no longer dreaming of what it was going to do, but was half-way through with its plans. It was spending £6,000,000 on the Morwell coal deposits; in 1923 briquettes made from that coal would be burned, and early in 1924 electrical energy would be supplied, not only in Melbourne, but throughout the whole State of Victoria. It was calculated that energy would be furnished to manufacturers at £4 8s. 0d. per horse power and at the mine's mouth at £2 17s. 6d. Cheap power and cheap fuel meant great prosperity throughout the land. What a desirable home the State would then be for people going to it from this country—low taxation, cheap power, a magnificent climate and comparatively few people! Capitalists would be welcomed there to start new industries, and immigrants from this country could not only be settled on the land but have employment provided for them in the great industries that would be started in Victoria. Victoria intended to confine its immigration policy to British people. Australia meant to keep itself a "white country" and did not mean to let itself be filled with alien races. Ninety-seven per cent. of its people were British people and Australia was going to remain the outpost of the white race. That was why he said that British people were interested in the fact that Australia had such magnificent resources. It had, as the author said, the greatest brown coal deposits in the world. The outlook was a magnificent one with regard to coal, to say nothing of the by-products, and the people of Victoria intended to do their utmost to get as many people as possible from Great Britain to help to develop their grand and beautiful country.

DR. MARIE C. STOPES, F.L.S., said that the bituminous black coals had been the ones in which she had been more publicly interested, but nevertheless, in her laboratories, she had been very much interested in lignites and brown coals for some years, less from the point of view of their commercial value than from that of their great significance in the theory of coal formation. She would like to say a word or two on the more academic aspects of the significance of brown coals, for, although commercial and wordly prosperity was the desire of statesmen and of the nation, without vision the people perished, and the scientist had the vision which led ultimately to discovery in commercial research. There was one point in the newer lignite coals which Professor Bone did not lay great stress upon, but which was of great importance. It was on the whole, though not entirely, true that the age-maturity corresponded with the actual chemical-maturity of a coal: and that meant that the brown coals and lignites were a mass of semi-decomposed plant material of a different type of vegetation from the material which formed the bituminous coals

of the earlier geological epochs. Therefore she did not hesitate to prophesy that when at a later period, perhaps ten or more years hence, people really went in detail into the by-products of the different forms of coal, very useful *new* by-products would be found in the lignites which could not be obtained from the bituminous coals. Owing to the evolution of higher forms of plant life, new substances that at present might be too subtle for the chemist to detect were present in the lignites and brown coals, which should, therefore, be regarded not only as a source of energy, but as a source of more valuable and subtler chemical by-products. One little illustration of that might be of interest. She had had sent to her by an important Government official in New Zealand some samples of lignites from that country, and when she unpacked them she found amazingly large lumps of pure resin in those lignites such as she had never seen before, and she thought she had seen all the leading collections of coals in the world. In that feature the lignites were unique. She wished to offer a word of congratulation to the author for having been brave enough to tackle the subject of lignites. Many professors ignored their existence.

Commander Carlyon Bellairs, M.P., said that twenty years ago he read a paper before the Royal Society of Arts on the coal resources of the British Empire, and he had listened to the present paper with the very greatest interest. He had been ignorant of the extent of the resources which had been opened up in Victoria, having only read short accounts about them in the newspapers, and it was perfectly marvellous to him to hear how those resources were being developed and would be at the disposal of the Empire. He would like to know whether the State had undertaken their development, or whether it was going to be done by private enterprise.

The Hon. John McWhae said the State was carrying out the work.

Commander Bellairs, continuing, said he hoped the resources would be rapidly developed, and he was glad that Lord Northcliffe had devoted his attention to the question of population, because where the coal and the transport were, there the population would go. He remembered that when he wrote his paper on the coal resources of the Empire, he fell foul of Prof. Jevons's theory that the fuel resources of the world were becoming exhausted. That was a theory that so possessed Mr. Gladstone, when he was Chancellor of the Exchequer, that he brought in a Budget for getting rid of the national debt, because he said that by getting rid of its coal the country was getting rid of its capital. The first slide shown by the author, indicated that the coal resources of the world totalled over seven million million tons, and he was delighted to see that since the time when he wrote his own paper, the resources of Canada had been calculated at between one-sixth and one-seventh of the resources of the whole world. That showed the very great wealth of coal that existed within the British Empire.

Professor Henry E. Armstrong, F.R.S., said he thought the author had brought forward two points of great importance. The first was that it was possible to get rid of the water in brown coals and lignites economically, and the second point was the work that he had done in increasing to a very great extent the fuel efficiency of those materials by preliminary heat treatment. He took it that the fact that the author's process made it possible to burn them at three to four times the rate of the raw material meant a great deal; it meant that they were fuels which could be used for purposes for which the ordinary lignites could not be used During the last century, at all events, the people of this country had fed themselves almost entirely upon coal and there was very little else left for them to feed upon. The public did not realise that sufficiently. He thought the prospect which was being opened out in Australia and Canada was not altogether a pleasing one.

The extent to which we would be able to feed upon coal was obviously going to be materially diminished if people elsewhere could feed upon it directly and not through Great Britain; and that was what was going to happen. It was a serious matter for us at the present time, that all over the world people were learning to do their own washing and not allowing us to do so much of it for them, and this country was going to suffer very seriously thereby. Personally, he knew something of Australia, and, although he could congratulate Australia on developing in the way it was doing at the present time, he did not think the people of this country would regard with pleasure the prospect of Australia spoiling itself by becoming industrialised. He would rather that Australia retained its beauty than that it made itself hideous in the way in which this country had been made hideous.

Dr. F. Mollwo Perkin, C.B.E., F.I.C., F.C.S., said he had examined the Morwell deposits and for sheer beauty of material he had never come across such splendid products. The amount of ash in the Morwell deposits was practically nil; they were far superior to any deposits obtained from Germany, and from what he had heard, he understood that the mining of the Morwell deposits was extraordinarily easy. He had carbonised large quantities of the coal, and had obtained most splendid oils therefrom, these oils having an extraordinarily low sulphur content.

Furthermore, the oil produced on low temperature carbonisation, say, at 480 deg. C., gave an extremely good spirit—petrol—and a good lubricating oil could also be obtained. He had briquetted the material and it formed a most excellent briquette, which produced a very small quantity of ash. The great trouble in the use of briquettes—which were often made from inferior coal—in this country at any rate, was the large amount of ash dust produced; that was a disadvantage, because the average householder did not like a large amount of ash to be deposited in the form of dust over the house. The Morwell brown coal deposit was far superior to the German; it contained about 15 per cent. of moisture, at the most, and the German very often contained up to 40 or 50 per cent. of moisture, yet the Germans were able to mine it, and to obtain a product which was commercially successful. He believed some of the German companies working these deposits had made nearly 20 per cent. profit, even with 50 per cent of moisture. The Morwell deposit did not contain so much moisture, and it was very much more readily mined It had got an over-burden of china clay; he had analysed the china clay, and found it was of a very good quality He agreed with Professor Armstrong in not wishing the Dependencies of Great Britain to produce everything for themselves so that we could not sell our home products to them, but at the same time, he did not think this country wished to supply Australia with coal. It could supply Norway and Sweden with its products, and it could briquette a great deal of its raw material, the slack and dust, which at present was going to waste. Therefore, he could not see what objection this country could have to Australia developing its own resources; in fact, he thought it would be a very good thing if Australia would develop its wonderful brown coal, and Canada its lignites He did not know that there was much brown coal in Canada, but he had seen lignites there, and he knew they were of a very good quality. The brown coal in this country—for example, in Devonshire—which the Germans were developing before the war, was not nearly so good, and yet the Germans came to England and found it worth their while to try to develop it, until the war broke out and put an end to the business

THE HON. SIR EDWARD LUCAS (Agent-General for South Australia) said he thought the paper had been a remarkably interesting and lucid one on a topic which was certainly of very great interest and very great importance to the whole of the British Empire. The continual, and rapid diminution of our stores of anthracite necessitated on the part not only of the home Government, but of all the Dominion Governments, very great watchfulness and energy in the development of such stores of coal as there might be in the Dominions The Hon. Henry Newman Barwell, Premier of South Australia, would arrive in London in a day or two, and one of the objects he had in coming to this country was to find out all he could with regard to the best and latest developments in the utilisation of brown coal deposits. Just across the banks of the great River Murray, which ran through South Australia, there had been recently discovered an enormous deposit of brown coal. He thought one of the things that ought to be undertaken in every part of the British Dominions was the appointment of Royal Commissions of expert men, and women if need be, who would do what the Conservation Committee appointed by President Roosevelt did. He held the view that one of the best things President Roosevelt did for the United States was the appointment of a National Conservation Commission, and one of the most interesting reports he had ever read was the one issued by that Commission It reported upon the national resources of the United States in regard to three things in particular—the conservation of the minerals in the United States, the conservation of the forest timbers, and the conservation of water He thought the British Empire ought to take the matter in hand at the earliest opportunity and appoint capable men to go into the question, because great national resources were always lessening in quantity, and reports ought to be brought out as to the available supplies and the best means of conserving them. He hoped the home Government would deal with the subject in the very near future. With regard to the question Commander Bellairs had asked as to whether the brown coal deposits in Victoria were being developed by the State or by private enterprise, he would like to mention that there was not so much to fear from governmental enterprise in Australia as there was in this country. The Parliaments there were comparatively small, and the men who were sent there were much more amenable to discipline than were the 707 members who comprised the House of Commons in England. He had very great pleasure in moving a hearty vote of thanks to the author for his excellent and illuminating paper

SIR CHARLES S. BAYLEY, G.C.I.E., K.C.S.I., in seconding the motion, said he would like to add a most hearty vote of thanks to the Chairman He was a little disappointed that nobody had spoken about the brown coals and lignites of India. Besides being very much interested in India generally, he happened to be the Chairman of the Indian Section of the Royal Society of Arts, and it would have given him great pleasure to hear some remarks about products, coals and lignites of that country, which apparently existed from Nepal and the Darjeeling district down to Bombay. He hoped that

somebody would be found to take the matter up for the benefit of India.

The resolution was carried unanimously.

PROFESSOR BONE, in reply, said his difficulty in preparing the paper had been not what to put in, but what to leave out. The subject was a very wide one, and, although there was much that had yet to be learned about it, sufficient was already known to form the subject of a course of lectures. He would have liked to have the opportunity of giving further particulars of the work that had been done on the by-products obtainable from the various coals he had described; perhaps on another occasion he might be able to do so. He had tried to draw attention in the paper, not only to the extreme importance of the subject to the Dominions from a commercial aspect, but also to the necessity of having it thoroughly investigated on scientific principles, now that its development was still in what might be called the initial stage. He quite agreed with Dr. Stopes as to the value of scientific research, properly directed, in the case of such problems as that under discussion, provided that it was taken up *ab initio*, when the whole subject was in in early stages of development. He, therefore, hoped that when the Governments concerned took up the question of the commercial exploitation of the coal and lignites, they would not forget the importance of having it thoroughly investigated in all its scientific aspects, so that the latest knowledge and research might be brought to bear upon it. If they neglected that they would neglect a very important duty. He, therefore, wished to plead for the proper scientific investigation and development of the immense potential resources of brown coals and lignites which occurred in almost every part of the Dominions.

The meeting then terminated.

MR. CYRIL S. FOX sends the following addition to his note incorporated in Professor Bone's paper:—The vast lignite deposits of Saskatchewan in Canada and the great beds of brown coal in Victoria in Australia, have already been investigated and found capable of profitable development. It is true that the unpalatable fact has been discovered that no successful method of briquetting lignitic coals without a suitable binding material appears to be known outside Germany and that, as a result, the Dominion Government contemplate erecting plant on the American system of carbonising their lignite to 600° C., and briquetting it with a binding material of coal tar pitch. They estimate a production of 100 (short) tons a day. The Commonwealth Government, on the other hand, appear to have negotiated with Leitz and Co., of Halle, for direct briquetting plant. They contemplate at first an output of 96,000 tons of briquetted brown coal a year, although they estimate that the smallest successful commercial plant should utilise six presses capable of turning out 300,000 tons of briquettes a year. The cost of the smaller plant is estimated at £86,000 plus another £264,000 for boilers, buildings, conveyors, electrical plant, etc.—giving a total of £350,000. The cost of the larger plant is estimated at a total of £750,000. The question of size of the briquettes has been discussed. Small sizes, 2 to 8 ozs. each, are recommended for local consumption and larger briquettes, up to 2 lbs. weight each, for export purposes.

Some idea of the German developments in the use of briquetted fuel may be gauged from the fact that the Lauta Aluminium works in East Germany are to be supplied with 60,000 kilowatts of electrical energy which will be obtained from briquetted lignite. The full significance of this can only be appreciated when it is understood that the *sine qua non* of the electrolytic production of aluminium is cheap power—so far invariably obtained from very favourably located hydro-electric projects. There are likely to be many possible demands for the briquetted lignite from the Travancore littoral supplies for the coastal shipping; for the South Mahratta Railway through Marmagoa; for various potential chemical industries, such as the establishment of cement works, the purification of bauxite in the production of alumina, the manufacture of magnesium sulphate from bitterns, the preparation of fish manure, etc.—if the lignite proves suitable for direct briquetting and can be prepared cheaply for supply to the west coast of India.

In many ways the Travancore area appears to offer an attractive field for investigation. At present little is known. There are said to be nodular accretions of resinous matter in these lignites which may prove of economic importance in a subsidiary way. But a full preliminary examination of the area is urged. If the results are encouraging, attention may later be turned to the buried resources of the Trichonopoly District of Madras and to other tracts of India. A French company was floated to work the Pondicherry area, but a "hitch" which occurred was purely a financial one. It is to be regretted that these areas have not received the attention they deserve. The question becomes more pressing each year, and now that briquetting is an established method of marketing friable fuels, and the Froth Flotation process for cleaning and drying low grade coals has been shown to be both economical and advantageous, it is evident that the time is ripe for a re-investigation of some of the more favourably located occurrences of Indian lignite.

All reference to the occurrence of peat in India has been omitted in this note. It is questionable whether the term peat is applicable to the accumulations of vegetable matter which have been reported as peat in Lower Bengal and in the Lake District of Kumaon and in Kashmir. These deposits are not considered as of any economic importance.

Large areas of true peat are, however, known to occur in the Nilgiri Hills of South India. The bogs in which this peat is found occur at elevations above 6,000 feet. Fifty years ago (see *Journal Society of Arts*, Vol. XIX., 1871, pages 201 and 266) recommendations were made by a Col. R. Wraage for utilizing this fuel on the Madras railways. This peat was used as fuel in Ootacamund, but difficulty appears to have been experienced in drying it sufficiently. The question of development does not seem to have been re-opened.

CORRESPONDENCE.

SURFACE COMBUSTION.

My attention has been drawn to a statement made by my friend Professor H. E. Armstrong (on p. 305 of your issue for 10th March, 1922) in the course of a discussion on Mr. E. V. Evans's recent paper before your Society upon "Some Solved and Unsolved Problems in Gas Works Chemistry," which I think calls for some correction. Professor Armstrong, in referring to a particular application of my well-known discovery of flameless incandescent surface combustion, formerly known as the "diaphragm" but now as the "radiophragm" method of heating as applied to grilling and roasting operations, said that "unfortunately the flame lit back."

I think Professor Armstrong must have here spoken under some misapprehension, and I therefore wish to place on record the following statement with a view to putting the matter right.

The original radiant surface combustion "diaphragms," as designed by my late collaborator, Mr. C. D. McCourt and myself, and manufactured in Leeds to our instructions, did not back-fire when run on explosive mixtures of the then coal-gas and air, and when freely radiating according to the conditions which they were designed to meet. Such diaphragms were normally kept running for the whole day in our experimental station at Leeds without any signs of back-firing; and they were exhibited and demonstrated in various parts of Great Britain, America, and Germany with never a complaint of the kind referred to. I have still one or two of the old diaphragms by me, which were made in accordance with our original specification, and they do not back-fire, even when used on present day gas.

There are admittedly conditions under which such diaphragms can be made to back-fire, e.g., if their free radiation is so impeded as to allow of too great an accumulation of heat in the incandescent layer, which is the seat of the intensive combustion. Moreover, if diaphragms are made of an unsuitable grade or character, and not in accordance with the original specification, it is not unlikely that back-firing will occur. Possibly it is this latter circumstance which may have lent some colour to Professor Armstrong's suggestion. But if the diaphragms are properly made, in accordance with the original specification, and used under conditions for which they were originally intended, there will be no back-firing trouble.

In connection with the subject of these "radiophragms" (as they are now termed) I may perhaps be allowed to add that, largely owing to the patient efforts of Mr. F. J. Cox, the technical manager of Radiant Heating Ltd. (the original company formed to pioneer my surface combustion inventions), considerable improvements have recently been made in the manufacture of the diaphragms, whereby they can now be made of a uniform grade and texture in large quantities. They are now being largely used, not only in hotels and restaurants for grilling and cooking purposes, but also in confectionery and biscuit factories, and the demand for them is rapidly developing, because of their remarkable radiant efficiency, and of the fact that the explosive mixture of gas and air in the proportions for theoretical combustion is burnt intensively in the incandescent surface under conditions which can be perfectly controlled

WILLIAM A. BONE.

PRODUCTION OF BLACKSTRAP MOLASSES IN CUBA.

The principal dealers in Cuban blackstrap molasses state that a fair average analysis of this product will show 10 to 17 per cent. water, 36 per cent. Clerget sugars, 16 per cent. glucose, and the remainder fibre, gums, and salts, the last named being by-products which are not now utilized.

It is claimed, says the United States Vice-Consul at Havana, that under an efficient process the average gallon of blackstrap molasses will distil from 0.3 to 0.5 gallon proof alcohol. It would, therefore, appear that few products are better adapted to the manufacture of alcohol. Producers and dealers in the Havana district express the opinion that the demand for blackstrap molasses will steadily increase, especially if alcohol comes into general use as a substitute for petrol in running motors. Moreover, it is believed that the growing demand for the use of raw molasses in the manufacture of certain stock foods will offset the loss of the market occasioned by the prohibition of the manufacture of alcoholic beverages in the United States.

Owing to the high price of sugar as compared with that of molasses, the latter product is often burned by the sugar mills as fuel in connection with other refuse, instead of being stored until shipment can be made A proper interest in the storage and conservation of blackstrap molasses by the sugar mills depends largely on the offering of a fair market price; and if excessive profits are gained by any of the parties handling the product, the margin will become too narrow to be profitable to the others

A more careful conservation would also create a demand for steel storage tanks both at the sugar mills and various points of shipment. It is stated that the port of Matanzas has storage capacity for over 16,000,000 gallons; Havana, 8,000,000; Cienfuegos, 6,000,000, Santiago de Cuba, Monaco, Jucaro, Antilla, Nuevitas, and Puerto Padre 2,000,000 to 3,000,000 gallons each; Boqueron, Caibarien, and Sagua under 2,000,000 gallons each Important improvements are under way at Matanzas and it is believed that additional storage will soon be available at that point Approximately 765 tank cars of 5,000 gallons each are held by shippers of molasses, and the United Railways have available some 40 tank cars of less capacity

The estimated production of molasses in 1920 was 180,000,000 gallons

HYDROGENATION OF OILS IN JAPAN.

The hardening of fish and vegetable oils by hydrogenation is a comparatively recent industry in Japan, having been started in 1912, with one factory under foreign management. Originally the industry was intended to furnish hardened oils for soap making, but owing to recent developments there is now a small surplus for export The extent of the trade may be estimated by the fact that in 1918 hardened oil amounting to 788,673 pounds, valued at about £19,000, was exported, but in 1919 and 1920 the exports evidently were smaller, as hardened oil was not listed as a separate item in the customs returns for those years

According to a report by the United States Vice Consul at Kobe, there are now eight plants in Japan manufacturing hardened oil by the hydrogenation process, with a combined capacity of 62 tons per day The raw materials used by most of these plants are whale and fish oils, although a few also harden vegetable oils (principally coconut and soya bean), or fish and vegetable oils mixed Some of the plants obtain their hydrogen used by the decomposition of water by electrolysis, which can be done profitably in Japan, where electric current developed by hydro-electric plants is plentiful and reasonably cheap. Others use hydrogen obtained as a by-product from the manufacture of caustic soda, or by the action of acids upon metals. The processes employed in most of the factories are not made public, but it is known that one concern uses a Japanese patent similar to the German Wilbuschwitch patent, and another has the sole right to the Ellis patents in Japan

The Japanese soap industry, which furnishes the principal market for the hardened oil, has tripled in size during the past ten years, and in 1919 the output amounted to some £3,000,000 This quantity not only supplies domestic needs but leaves a surplus valued at about £400,000 for export In 1920, 2,000,704 dozen cakes of toilet soaps and 6,928,380 pounds of laundry soaps were exported, principally to China, India, the Dutch East Indies, and other parts of the Far East

The hardened oil industry has developed with and is dependent upon the soap industry for its prosperity As a result of the severe trade depression, consequent upon deflated prices and the breakdown of foreign trade, the market for soap has decreased considerably, with a corresponding decrease in the home demand for hardened oil At the same time the market abroad, which formerly absorbed the small surplus, has practically disappeared Consequently, producers of hardened oil in Japan have had a bad period, although most of them are still operating No improvement can be expected in the industry until trade conditions in general, and the oil and soap markets in particular, show indications of settling down The hardened oil industry in Japan, adds the Vice-Consul, should develop considerably in the future, as Japan has abundant supplies of fish and vegetable oils and a steady market at home for part of the output

A NEW FLAX SEED

Attention is drawn in the *Times Trade Supplement* to the production of a new pedigree flax seed by Dr Vagas Eyre, the director of the Linen Research Association Institute, near Lisburn He has discovered, among the fresh varieties of flax seed which his scientific methods of fertilisation produced, two of the Livonian strain, which on being tested yielded 80 per cent. more fibre than any other seed on the market, while the quality of the fibre was on the average two grades higher In fact, taking these two items into consideration, it is not an exaggeration to state that the return is 100 per cent. better than from the Dutch flax seed hitherto grown. An increased return of this order would not only mean a larger supply of raw material fibre at a low cost, but according to Mr. J. G. Crawford, a well-known linen manufacturer, more easily spun yarns of a more uniform quality Hence the importance of this discovery to the linen industry.

Naturally, the production of this pedigree seed in any quantity will take time. It required years before from one single pickle there was evolved one pound weight of seed, but the work was patiently continued until now there

are approximately five tons available. Its further distribution and commercialisation is under consideration, and while a portion will be given to careful Irish flax growers, another quota will be developed at the National Institute of Agricultural Botany at Cambridge, while the remainder will be sent to Canada, where climatic conditions are favourable for seed development.

GENERAL NOTE.

INDIA OFFICE LIBRARY.—The annual report of the India Office Library for the financial year 1920-21 shows that there were 3,001 readers, while 1,888 books were taken away on loan and 67 MSS. and xylographs lent. The accessions numbered 7,581, of which 3,401 were issues of periodicals. There were also received 632 Archæological Survey photographs, 6 gramophone records of dialects spoken in Delhi; 37 transcriptions and translations of gramophone records of languages spoken in the Central Provinces and Berar; Tibetan MS. fragments (transferred from the British Museum); 4 Tibetan xylographs; 10 Arabic MSS., 1 Persian MS., MS. Journal of Major-General James Welsh, 1845-48; 84 Siamese books (presented by the Vajiranana National Library, Bangkok), etc. The pre-war exchanges with foreign institutions and societies have in a great measure been restored. Amongst the donees of books in the 12 months under notice were the Preussische Akademie der Wissenschaften (Berlin) and the Bibliothek der Bayerischen Akademie der Wissenschaften (Munich) The printing of Professor Keith's catalogue of Sanksrit MSS. was postponed for reasons of economy.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

APRIL 5. — PROFESSOR ERNEST R. MATTHEWS, "Coast Erosion and its Prevention." LORD HEADLEY, M.Inst.C.E.I., in the chair.

APRIL 26.—JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the chair.

MAY 10.—MAJOR PERCY A. MACMAHON, R.A., LL.D., ScD., F.R.S., "The Design of Repeating Patterns for Decorative Work." SIR CHARLES CARRICK ALLOM in the chair.

MAY 17.—OSWALD M. SHEPHARD, "Recent Developments in Rubber Manufacture, with special reference to Rubber Machinery and the Manufacture of Tyres."

MAY 24.—GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

MAY 31 (at 4.30 p.m.)—LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

APRIL 28.—F. G. ROYAL-DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the chair.

MAY 26.—SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced:—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION

TUESDAY, APRIL 4, at 4.30 p.m.—LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "New Zealand." COL. HON. SIR JAMES ALLEN, K.C.B., High Commissioner for New Zealand, in the chair.

FRIDAY, JUNE 9, at 4.30 p.m.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETING.)

Friday afternoon, at 4.30 o'clock:—

MAY 5—PROFESSOR WILLIAM HENRY ECCLES, D.Sc. (London), F.R.S., "Imperial Wireless Communication."

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constituents of Essential Oils." Three Lectures. March 20, 27, April 3.

Syllabus.

LECTURE III.—APRIL 3.—The Derivatives of Benzene. Alcohols. Acids and Esters. Aldehydes. Phenols and their derivatives. Heterogeneous Compounds. The Trend of Modern Research. The importance of the Essential Oil Industry to the British Empire.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, APRIL 3 .. Geographical Society, 135, New Bond Street, W., 8 30 p.m.

Farmers' Club, at the Surveyor's Institute, 12, Great George Street, S.W., 4 p.m. Mr. R. B. Matthews, "The Uses of Electric Power in Agriculture."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Messrs. E. R. Sutcliffe and E. C. Evans, "The Effects of Structure on the Combustibility and other Properties of Solid Fuels."

Electrical Engineers, Institution of (Western Section), Swansea, 6.30 p m

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. S. C. Ramsey, "London Clubs"

Royal Institution, Albemarle Street, W.. 5 p m. General Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. H Bentham, "Fractures in Concrete"

TUESDAY, APRIL 4 .. Royal Institution, Albemarle Street, W , 3 p.m Prof. J. W. Evans, "Earth Movements." (Lecture II.)

Alpine Club, 23, Savile Row, W., 8 30 p.m. Mr. G. A. Solly, "British Mountaineering: its Development and Contrasts."

Marine Engineers, Institute of, 85, The Minories, E.C., 6.30 p m. Sir D Wilson-Barker, "Animal Life at Sea, including all Living Things generally seen, with Notes on Flight"

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Photographic Society, 35, Russell Square, W C, 7 p.m. Mr. H. Lambert, "Imaginative Portraiture."

Electrical Engineers, Institution of (N. Western Section), 17, Albert Square, Manchester, 7 p.m.

WEDNESDAY, APRIL 5 . Central Asian Society, at the Royal Society, Burlington House, Piccadilly, W, 5 p.m Mr. R. Williams, "The Cape to Cairo Railway from the Point of View of African Development."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W, 8 p.m. 1. Messrs. O. D. Roberts and H. T. Islip, "The Constants of Indian Beeswax." 2. (*a*) Mr. A. C. Chapman, "Note on the Liver Oil of the 'Tope' (Galeus galeus)." (*b*) "Note on the Examination of Foods for the presence of Sulphites." 3. Mr. S. H. Groom, "Demonstration of Artificial Daylight for Laboratory Purposes—Sheringham System." 4. Mr. A. Bruce, "A Tropical Milk Supply." 5. Messrs. E. R. Bolton and D. G. Hewer, "Certain Tropical Oilseeds."

University of London, South Kensington, S.W.. 5 p.m. Sir Frederick Bridge, "Sir W. Leighton's Great Collection of Early 17th Century Motets, by Eminent English Composers." (Lecture V.)

Electrical Engineers, Institution of (S. Midland Section), The University, Birmingham, 7 p.m.

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W.. 11 a.m. Annual Meeting. 1. Presidential Address by the Duke of Northumberland 2. Sir Westcott Abell, "Merchant Shipping and World Commerce in Relation to Sea Power." 3. Mr. J. H. Narbeth, "Three Steps in Naval Construction—King Edward VII.—Lord Nelson—Dreadnought." 3 p.m. Mr. J. L. Kent, "Resistance of Ships Among Waves."

THURSDAY, APRIL 6 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mons. L. Breguet, "Aerodynamical Efficiency and the Reduction of Air Transport Costs."

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. 1. Dr. A. B. Rendle, "An Example of Regeneration of the Terminal Bud." 2. Mr. C. Turner, "The Life-history of *Staurastrum Dickiei*, var. *parallelum* (Nordst.). 3. Mr. L. C. Borradaile, "The mouth parts of the Shore crab, with lantern slides."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. Macleod Yearsley, "A Plea for the Deaf Child."

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. M. Hind, "Landscape Etchers." (Lecture II.)

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W., 11 a m. Annual Meeting continued. 1. Dr. J. H. Smith, "Nodal Arrangements of Geared Drives." 2. Mr. J. W. Wilkie, 'Double Reduction Gears in the s.s. *Melmore Head*." 3. Mr. T. C. Tobin, "A Method of Determining the Natural Periods of Vibration of Ships." 3 p.m. 1. Mr. J. Reid, "Possibilities of Fuel Economy in Marine Boilers" 2. Mr. J. L. Hodgson, "The Metering of Steam." 8 p.m. Mr. James Richardson, "Diesel Machinery for Single Screw Motor Ships."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C, 6 p.m. Mr. J. A. Kuyser, "Protective Apparatus for Turbo-Alternators."

Dyers and Colourists, Society of (West Riding Section), Mr. A. Jackson, "The Finishing of Fine Worsteds and Woollens."

Chemical Society, Burlington House, Piccadilly, W , 8 p m. 1. Messrs. M. O. Forster and W. B. Saville, "Constitution of picrorocellin, a nitrogenous constituent of *Roccella fuciformis*." 2. Mr. S. Sugden, "The Determination of surface tension from the maximum pressure in bubbles"

FRIDAY, APRIL 7 .. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Dr. C. W. Saleeby, "More Light on London ; or The Coal Smoke Curse and the Restoration of Daylight."

Cyclists Touring Club, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m.

Royal Institution, Albemarle Street, W , 9 p.m. Sir Ernest Rutherford, "Evolution of the Elements."

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W. 11 a.m. 1. Mr. E L. Champness, "Longitudinal Strength of Cargo Vessels and its Variation with Fullness of Form." 2. Prof. C. E. Inglis, "Some Special Cases of Two-dimensional Stress or Strain." 3. Mr. John Tutin, "The Economic Efficiency of Merchant Ships." 3 p.m. Mr. J. R. Barnett, "Recent Developments in Motor Life-Boats."

Chemical Industry, Society of (Manchester Section), at the Textile Institute, Manchester, 7 p.m. Annual General Meeting. Prof. J. S. S. Brame, "Oil-Fuel ; its Application and Economic Limitations."

Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. J. W. Maple, "Engineering in Southern Persia."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. Mlle. M. Vigoureux, "Eugene De la Croix et l'Ecole Romantique."

Aeronautical Society (Students' Section), 7, Albemarle Street, W., 6.45 p.m. Prof. L. Bairstow, "Some Aeronautical Problems of the Early Future."

SATURDAY, APRIL 8 .. Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Radio-Activity." (Lecture VI.)

Chromatics, International College of, Caxton Hall, Westminster, S.W., 3.15 p.m. Mr. E. K. Robinson, "Trees : their Colours and Colouration."

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday morning of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 341.

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FRIDAY, APRIL 7, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 29th, 1922, SIR ROBERT ARMSTRONG-JONES, C.B.E., M.D., F.R.C.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society:

Morgan, N. L., B.Sc., Quebec, Canada
Pillay, G. Hurry Krishna, M B E, Rangoon, Burma.
Rayner, George Jabez, Victoria, British Columbia.
Kamla, Pat Sahai, London
Starr, Mrs. Ida M H., Easton, Maryland, U.S A.

The following candidates were balloted for and duly elected Fellows of the Society:

Roberts, Alfred Edwin Priestland, Birmingham.
Vardy, William Andrew Shakespeare, Normanton.

The Shaw Lecture on "Alcohol in Relation to Industrial Hygiene and Efficiency" was delivered by Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P.

The lecture and discussion will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

On MONDAY, APRIL 3rd, MR. GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, delivered the third and final lecture of his course on "The Constituents of Essential Oils."

On the motion of Mr. F. Lewis, a vote of thanks was accorded to Mr. Radcliffe for his interesting course.

The lectures will be published in the *Journal* during the Summer recess.

DOMINIONS AND COLONIES SECTION.

TUESDAY, APRIL 4th, 1922; COLONEL THE HON. SIR JAMES ALLEN, K.C.B., High Commissioner for New Zealand, in the Chair.

A paper on "New Zealand" was read by LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 1ST, 1922.

MR. PERCY A. SCHOLES, Music Critic of the "Observer," in the Chair.

THE CHAIRMAN said that Mr. Emanuel Moor, on the plea that he could not speak English very well, had asked him to give a description of the Duplex-Coupler Pianoforte, which was the subject of the meeting that evening. Personally he had not invented the piano and he had not even seen the inside of it, but he had heard it played, and some weeks ago Mr. Moor had explained it to him. He had also read two articles in the "Times" on the subject, an excellent article by his friend and colleague, Mr. Ernest Newman, in the "Musical Times," and a lengthy and very instructive article in "Music and Letters" by Prof. Donald Tovey, the Professor of Music at Edinburgh University. From those various sources he had gathered the following information. The Duplex-Coupler Piano was designed to do away with a great many of the present difficulties in piano playing. He was sure many people would welcome it on that account, because not only would it enable them to play the piano more easily and better, but it would do away with a great

deal of their neighbours' children's practising. There were many passages—passages difficult to stretch, passages of jumps, passages of octaves—which became perfectly simple when played upon the Duplex-Coupler piano. As far as he could judge from his small knowledge of the instrument, what it did was to bring distant things nearer together. It had two keyboards, but only one set of strings and one set of hammers. When one played upon the lower keyboard one played upon a normal piano and one need not use the upper keyboard at all, but if one used the upper keyboard an advantage was obtained from the fact that the upper keyboard played an octave higher than the lower or normal keyboard. Supposing, for instance, he wanted to play the note C and the E ten notes higher, instead of trying to grasp that extended interval on the one keyboard he could take the two notes quite close together upon the two keyboards. The two keyboards were so cunningly adjusted to one another that it was perfectly easy to play with one hand upon the two at the same time. He could play with his thumb on the lower keyboard and with any of his fingers on the upper keyboard; the C and E ten notes apart could be played three notes apart quite easily. The use of the two keyboards would also obviate the left-hand jumps that were such a trouble to the girl next door when playing a waltz. The instrument was so contrived that the two keyboards could be coupled together. The difficulty of playing passages in double octaves was well known; quite a lot of time was spent by the student in learning to play those octaves well and nobody could play them well in the sense of playing them really smoothly. With the two keyboards of a double keyboard piano coupled, however, which was done by depressing a pedal, single notes could be played which immediately became octaves, because a C, for instance, on the lower keyboard had a C an octave higher on the upper keyboard coupled to it. One could play simple little scales and be playing octaves all the time, and they could be played as smoothly as scales of single notes could be played on an ordinary piano. When a difficult piece of music was turned into an easy piece, something more was done than merely ministering to the natural laziness of people. They were enabled to play more artistically; their minds were no longer concentrated on conquering difficulties, but they were able to devote themselves to artistic performance. From his own personal point of view the great advantage of the Duplex-Coupler Piano was the following: He was tired of hearing difficult piano music played because it was difficult and of hearing it received with applause because it was difficult; he wanted to hear piano music played because it was beautiful and expressed something and he wanted to hear it received with applause for the same reasons. He had, as part of his daily duty, to attend concerts, and it was impossible for anyone to attend concerts as frequently as he did without studying and criticising not merely the performers and the composers whose works were being played, but also the audiences gathered to hear them. In every audience that came to hear, say, a piano concerto one found a number of people who were enjoying the music not because it was fine music, but because it was difficult to play or they imagined it to be so. He remembered hearing a piano concerto played a month or two ago and he had in front of him a little family party of about six people, who had one pair of opera glasses amongst them and passed them from hand to hand—they were there evidently to watch the pianist, and they were there to watch him as they would be in a music hall to watch a clever gymnast. When piano makers, instead of putting their own names on the side of their instruments, put there the name "Emanuel Moor," that would be a sign to everyone in the hall that the difficulties in the music that was being played had been overcome, and he hoped that the interest of watching instead of listening would also be at an end, to the great advantage of musical art. All he feared—and he hoped Mr. Moor would be able to remove his fear—was that the difficulties of playing the existing music having been overcome by Mr. Moor, fresh difficulties might be invented by cunning and diabolically-minded composers in order that a fresh race of pianists might astonish future generations upon the double keyboard piano, as the existing and past races had astonished this generation and their forefathers upon the present piano. He had not had the opportunity of questioning Mr. Moor on that point, and he would like to be completely satisfied about it. He would leave the meeting that evening feeling immensely cheered if he was assured

that Mr. Moor had not only abolished a great many of the difficulties in existing music, but invented an instrument which was not capable of producing a fresh crop of showy difficulties which would cause pianists still to continue to be looked at instead of listened to.

The following address was then delivered:

THE DUPLEX-COUPLER PIANOFORTE.

By Emanuel Moor.

The idea of this piano came into my head more than twenty-five years ago, but when I described it to various makers and musicians they all shrugged their shoulders as though the last word had already been said on the subject of pianoforte construction. I was, therefore, greatly discouraged, as inventors in other branches of science and art have often been. Two years ago, about 4 o'clock in the morning, I had a very vivid kind of dream that I was playing Bach. A great deal of Bach's music was written for an instrument that usually had two manuals and a pedal. Directly after I had had this vision I rose and dressed and went to a little farm that we owned, where there was an old upright piano, and I immediately investigated the question as to whether the mechanism could be adapted to have two keyboards I found it could, so a few days later I issued a pamphlet explaining all the possibilities which the Chairman has just described to you. This pamphlet did not help me very much, as every piano maker in Europe, and even in America, to whom I sent it, rejected the idea and said it was not possible to construct such an instrument. I was, therefore, obliged to obtain the help of two carpenters, and I installed myself in our farm and managed to make a piano that would play. Of course, it had not the perfection of a machine-made instrument, because a piano is a very exact and precise mechanism, but when I had got so far that the instrument gave out sounds I got a pianoforte manufacturer at Berne to come and see it. He said the idea was very good, but when I asked him to give an estimate of the cost of making such a piano he said he could not do so. However, three days later he wrote to me, saying that he was very interested in the whole idea, and if I would give him a share in the patents he would construct the piano for nothing. Of course, that meant a great saving of money to me, and we had this model made that is in this room now. A good many critics in Zurich and Basle wrote about it, and some of their articles reached Prof. Tovey, who came to see me last August. I did not know him before, but when he saw the piano he asked to be allowed to stay in our house for several weeks to learn it. He was kind enough to interest the musical critic of the "Times" in the matter, and that gentleman also came to see it. In that way news of it reached England, and the Aeolian Company approached me and came to an arrangement with me, and thus first instrument that you see here was imported. The pianos that will be constructed now in England will be much superior to this one.

Mr Moor then gave a demonstration of the duplex coupler piano, showing the advantages of the two keyboards—the notes on the upper keyboard being an octave higher than the corresponding notes on the lower keyboard—and of the arrangement for coupling the two together. He also showed that by the operation of a certain device the piano could be turned into a harpsichord, so that very good effects could be obtained in that way when playing classical music which had been conceived and composed for an instrument which had a richer sound than a piano. The old music had been written to a great extent in two parts, and two-part music when played on an ordinary piano sounded rather empty, the harmonics and so on being subdued.

Mr. Max Pirani then played on the duplex-coupler piano a Prelude and Fugue by Bach, from the original organ edition

The Chairman said that Mr Moor set out not as an inventor but as a composer. He was not an inventor who, instead of inventing a new sort of wireless apparatus or motor car or sewing machine, turned his thoughts to music, but he was a composer who, feeling the need for other means of expression and better facilities for self-expression as a musician, had discovered those means and those facilities. People in this country did not as yet know much of Mr Moor's music, though a few years ago several of his symphonies were played at the Queen's Hall and the famous Flonzaley Quartet had played a concerto by him. He wished to emphasise the fact that Mr. Moor had approached the subject as a musician and not as an inventor

Miss Winifred Christie then played a Sonata by Scarlatti in E major and a Bach Prelude, using the harpsichord device.

THE CHAIRMAN asked if the harpsichord tone was produced by the interposition of a small body of metal between the hammers and the strings

MR. MOOR said that was so The present was a temporary device but it answered the purpose for the moment. The real point would be that with the tiny hammers there would be great precision. If a metal string was plucked as in the harpsichord the effect was not as good as it was in the present case Some conservative people might think it was, but in reality it could not be so, because the friction never gave quite such a clear tone as when the strings were struck by the hammers The friction was enough to enfeeble the sound The two instruments had been compared and it had been proved that his was the better.

It was pointed out by a member of the audience that the gauge of the modern piano string was larger than the gauge of the harpsichord string, which would make a difference in the quality.

MR. MOOR said his intention was not so much to imitate the old harpsichord as to create a new sonority resembling that of the old instrument, but capable of producing piano and forte effects.

It was also pointed out that the true harpsichord mechanism could not produce the same intensity of tone as the hammer mechanism, and that the piano provided possibilities of expression which the harpsichord could not give, because the latter was purely mechanical

MISS CHRISTIE then played Brahms' Capriccio in B minor, not using the harpsichord device.

THE CHAIRMAN said the following questions had been handed to him in writing: "Prof. Tovey points out in 'Music and Letters' that the new instruments are likely to have very great improvements. Will there be a sub-coupler for lower octave as well as a super-coupler? Also, will it be be possible to strike any one note on both the lower and the upper keyboards simultaneously?"

MR. MOOR said it was not proposed to have a sub-coupler.

THE CHAIRMAN said he did not see that there would be any advantage in having one, as it did not matter whether octaves were played as super-octaves or as sub-octaves.

MR. MOOR agreed. With reference to the second question, an arrangement for that would ultimately be made; it was only a question of expense.

MR. PIRANI then played some passages from Liszt's "Campanella," an Organ Prelude by Bach in G major, and the Fugue that followed it.

In answer to a question as to whether there would be any possibility of having stops in the duplex-coupler pianoforte when the harpsichord arrangement was being used, the chief charm of the harpsichord being in the combination of different stops, which gave totally different effects, MR. MOOR said it would be possible, but it would greatly increase the cost. In the case of the piano differences of sound could be obtained by altering the touch, whereas in the harpsichord that was not so. It was not desirable to have too many resources, as it was possible to have too many intermediary effects from a musical point of view.

In answer to a question as to whether the weight of touch was the same whether one keyboard was being used or the two coupled, Mr. Moor said when the keyboards were coupled the touch was slightly heavier, because two hammers had to be put into action, but it was not so heavy as it would be if two notes had to be struck The slight heaviness was really an advantage, because quite a new inpulse was obtained. The touch was obviously not very heavy, because a chromatic scale could be played very quickly.

In reply to a question as to whether all existing music would have to be re-fingered for the duplex-coupler piano, if that piano was to be used by students, MR. MOOR said the fingering would have to be changed in a way, and THE CHAIRMAN said that point had been dealt with by Prof Tovey in his article in "Music and Letters." Prof. Tovey deprecated the bringing into existence of a new nota ion or a new system of fingering. He supposed that students would be taught how to adapt their music to the two keyboards if they thought they could obtain a better effect by the use of two keyboards. If a new system of notation was brought out, the music publishers would have to produce all the music in duplicate.

MR. MOOR said there was one further point he wished to mention On the organ the same piece by Bach or Handel could be played in the same style with quite different registration, and people who went to hear organists playing were delighted if the registration gave some variety In the case of the ordinary piano, the player could introduce differences in spirit and temper and feeling, but as far as the actual mechanical resources were concerned, they did not permit of any sort of variety. The Duplex-Coupler Piano, however, enabled a player to register the music in different ways and to obtain some results which it was absolutely impossible to obtain with an ordinary piano.

MISS CHRISTIE then played a Gavotte by Gluck on the harpsichord and a piece by Rosenthal.

MR. G. K. MENZIES (Secretary of the Society) said that it was the custom at the Ordinary Meetings for the Chairman to propose a vote of thanks to the reader of the paper In the present instance, however, at least 50 per cent. of the lecture had been given by the Chairman, and it was hardly possible for him to propose a vote of thanks to a dual entity of which he himself was quite a half. He (the speaker) therefore took upon himself to propose a very hearty vote of thanks to Mr. Scholes and Mr. Moor for the duet which they had given, and also to Miss Christie and Mr. Pirani for their admirable and artistic demonstration of the instrument.

The resolution was carried unanimously, and, the Chairman having briefly responded, the meeting terminated.

ELECTRICITY AND AGRICULTURE.*

In England and Wales there are 418,000 farms and small holdings, five-sixths of which are of less than 150 acres in extent. The problem of increasing the yield of all these undertakings is of the utmost importance to the welfare and safety of the country According to the author's experience, it is possible even in our own climate to raise much more food, reduce waste and failure, and stabilise the conditions of the Agriculturist by the use of electricity on the farm

Great progress in this direction has been made in America and Canada, and upon the Continent, whilst in our own country there are already some notable developments as in the district of Hereford and certain parts of Wales.

The farm, and particularly the small farm, is not an ideal situation for machinery needing skilled attention; it is usually also impossible to supply it with gas and costly to provide coal or heavy fuel. Electricity which can at once be used to give light, heat or drive machines is obviously the simple and flexible form of power service needed on the land, being so easily conveyed by overhead wires, without disturbance of the surface, and free to leave the line of the roads for any point where its services are needed.

The speaker put forward information upin the cost of using electricity for all general operations around the farm buildings, the saving to be effected by employing electric light in cow sheds, the improvement in cleanliness, reduction in waste of milk, cattle food, and other materials by removing the dark and difficult conditions which exist during a large portion of the year in these buildings. He showed also how readily an electric motor can be applied to driving different machines, for chopping cattle food, operating churns, milk separators, etc. These motors are entirely covered in from dirt and moisture, need no skilled attention, and can be moved about from place to place according to the work in hand, season of the year, etc.

More extensive applications of this form of power are applied to the ploughing of the land, whilst in other directions we find, as so often happens with the employment of electricity, that the incidental savings and economies resulting from it far outweigh any question of cost. For instance, it has already become the practice to dry hay artificially by means of electrically-driven fans This gives the farmer much greater control over his crops, and makes him more independent of the weather. In other districts there are records of the use of electric heating for the prevention of frost amongst stores of roots and vegetables, whilst already it is employed extensively for the drying of fruits in bottling factories and similar undertakings.

It is stated that in New Zealand over 9,000 farms are fitted with electric milking apparatus, which requires very little power, reduces the number of persons in charge, and goes a long way to provide the necessary cleanliness in handling milk

So far the application of electricity on the farm is largely a matter of employing methods which have already been tried and found successful in manufacturing industries. A safe and adaptable form of light easily installed in any building, old or new, a flexible means of driving machines independent of the use of fuel, the production of smoke, heat and fire risk, naturally commends itself to the farmer, who has once seen it in operation and can get the necessary supply of power, particularly so as experience shows that the actual amount of power required across the year is a very small matter on the farm; but in addition to this it is obvious that we may expect remarkable further developments as electrical engineers give more and more attention to these problems.

Already the use of electric heat has been successfully employed for incubation Electric light has been shown capable of increasing the yield of eggs, or at least increasing their yield during that period of the year when they are of the highest market value.

Other applications of electric power full of promise relate to the sterilization of milk, the treatment of green fodder preserved for winter use by the method known as ensilage, and last, but not least, there is a wide, and as yet but imperfectly explored, field, electro-culture. It has been known for a long time that plant growth could be stimulated by the discharge of electricity at very high tension in its neighbourhood, although the precise reason for this is yet comparatively obscure. Recent experiments on a practical scale have, however,

* Abstract of paper read by Mr. R. Borlase Matthews before the Institution of Electrical Engineers.

demonstrated that an extremely small amount of electrical power converted in suitable apparatus to a very high tension and discharged from overhead wires strung across the fields has a remarkable effect upon most forms of vegetable life, increasing their yield, and in many cases advancing the period of harvest. Although it is at least possible that this effect may be rather in the nature of a stimulant than a food, and due to some effect upon the plant which enables it to pick up nutriment from suitable land more successfully than it could do unaided, yet there is already sufficient evidence to justify careful and continued research in this direction.

AGRICULTURE IN SOUTH AFRICA.

Since the early days of settlement fruit and vegetable farming has been of vital importance to the white people of South Africa At first, they were compelled by force of circumstances to grow fruit and vegetables for their own consumption, and later on they undertook the culture of the vine Afterwards the production of wheat was found possible, and from these early beginnings eventually developed the main industry of South Africa, for, until the development of diamond and gold mining, the Union was exclusively agricultural and pastoral.

Although South Africa has surpassed all other countries in the production of diamonds and gold, yet farming actually remains the industry of the people and the industry that offers the largest scope for development The aggregate value of the agricultural products of the Union already exceeds that of mining, and with the agricultural resources of the country so little developed at the present time remarkable progress will undoubtedly take place in the future. The following particulars of the industry are extracted from an interesting report on the subject by the U S. Consul at Johannesburg :—

Nearly all farms in South Africa are large. Small holdings, except near the cities, are uncommon In consequence, a large proportion of the land is uncultivated, and there still remain vast areas which have never been touched by the plough As a rule, a large part of each farm is set aside as pasturage, and farming and cattle raising go hand in hand in nearly every instance.

The principal crops grown in the Union are maize, wheat, oats, kaffir corn, rye, barley, tobacco, cotton, and forage Tea is also produced to a limited extent in Natal; and the cultivation of sugar is confined almost entirely to that province. Maize is actually the leading crop, and, in fact, South Africa is now recognised in the principal markets of the world as one of the foremost fields for the production of maize of good quality.

On account of favourable climate and suitable soil maize is produced almost throughout the Union However, the maize belt is often defined as the country lying east of the 26th meridian, which may be traced by drawing a line between Algoa Bay, Bedford, Cathcart, Queenstown, Aliwal North, Wepener, and Bloemfontein, and thence north to Lichtenburg and Zeerust. The Transvaal is the largest producing Province of the Union, but the Orange Free State holds the record for growing the heaviest crop per square mile.

The production of maize has increased considerably in recent years. Besides supplying the local demand, 509,495,794 pounds were exported in 1918; however, in 1919 exports declined to 246,265,197 pounds On the other hand, wheat is not grown in sufficient quantity to meet the requirements of the country.

Oats hold a more important place than wheat in local agriculture. However, oats are not always grown for grain, but instead find a ready market in the form of food for horses and cattle. The yield averages from 17 to 24 bushels per acre.

As applied locally, the term "kaffir corn" includes both kaffir corns and durras. The former are indigenous to South Africa, and comprise the original red and white varieties, as well as the varieties improved from seed obtained from the United States. The durras are of North African origin, and include brown, white, and yellow durra. They are both non-saccharine sorghums. Kaffir corn is not only important as a foodstuff for the native (coloured) population, but it is also employed as a substitute for maize in feeding cattle.

The principal forage crops are lucerne, teff grass, and manna. The first-named is the most important, and wherever water can be procured this plant flourishes in nearly every part of South Africa. It is a hardy perennial of rapid and luxuriant growth, and under favourable conditions can be cut several times a year. Lucerne is peculiarly adapted to irrigation farming in semi-arid parts, and with the development of irrigation in the Union and the expansion of the live-stock industry its cultivation will undoubtedly increase. Besides being used to an increasing extent in the milk, butter, and cheese industry, as well as the pig industry, lucerne is also likely to become a more important supplement to veld grazing in the development of the beef export trade.

Tobacco is grown in various parts of the Union of South Africa, but the principal producing areas are the Magaliesburg and Kat River districts. In these two sections a light and medium tobacco of the Virginian type is produced; and in the Potchefstroom, Vredefort, Pietretief, Oudtshoorn, and Piquetberg districts a medium to heavy type of tobacco is grown; while in the Stellenbosch, Wellington, and Tulbagh areas a Turkish tobacco is found. Natal also produces a medium dark tobacco, which is largely employed in the manufacture of cigars and partly

in the manufacture of a cheap-grade tobacco for pipes.

The average yield of bright tobacco in South Africa is approximately 800 pounds per acre, while that of dark tobacco is about 1,000 pounds per acre.

The tobacco and tobacco manufacturing industries have experienced considerable change in the class of leaf and manufactured article required by the public during the past 10 or 15 years. Formerly a heavy type of tobacco was used, but now a light cigarette tobacco leaf is consumed more extensively. In the early days the principal demand was for dark and medium tobacco suitable for ultimate conversion into pipe tobacco and snuff. At that time, a fairly large percentage of each year's crop was put up by farmers into roll tobacco, the rolls being converted into pipe or snuff tobacco by the consumer. This practice still exists to some extent.

During more recent years factories for the manufacture of cut pipe tobacco and cigarettes have been established in the Union, and, in consequence, an increasing demand for tobacco of light or medium colour and fine or medium texture has arisen. This factor has encouraged the production of a leaf suitable to the manufacture of cigars. The production of colonial Turkish leaf has also been firmly established, and cigarettes are now made from locally grown Turkish tobacco.

Although the production of cotton was first attempted in South Africa about 50 years ago, success did not attend the efforts of the early planters, chiefly on account of labour and transportation difficulties, but partly on account of the lack of cultural knowledge. The Union Government undertook a series of experiments to determine the possibilities of growing cotton in South Africa. As a consequence, new interest in this industry was awakened, and now there are approximately 8,000 acres under the cultivation of cotton in the Rustenburg district, 2,000 acres in the Waterberg district, 100 acres in the Tzaneen section, 50 acres in the Transkei district, and 4,000 acres in Natal.

Planting takes place during October and November, and the picking begins in April and continues until June or July. In the Rustenburg district, the largest cotton-producing area in the Union, the best results have been obtained from the class of cotton belonging to the big boll group. The average yield is 250 to 300 pounds of lint per acre. In some sections where light frosts occur growers practise "ratooning," that is, they permit the plants to stand for two or more years instead of ploughing the land each year and planting again. The yields are, as a rule, better from "ratooned" fields, and the lint does not appear to be of a lower quality. In any event, this method of cultivation decreases materially the cost of production, but it can be practised under favourable conditions only.

Ginning is done chiefly in the Rustenburg, Pretoria, and Lydenburg districts, and also upon the Maboki estates and at Tzaneen as well as in Natal. The gin at Rustenburg has a capacity of approximately 8,000 pounds of lint per day, and those at Pretoria and Maboki can deal with 3,000 pounds per day.

The surplus cotton-seed is generally used as food for cattle. The seed is delinted, and ground into meal without being decorticated. The production of cotton-seed oil has not yet assumed any importance, but with the expansion of cotton planting it should develop accordingly.

Tea is grown principally in the Province of Natal, where it thrives best at an altitude of 1,000 feet. It was first planted as an experiment at the Durban Botanical Gardens in 1851. For a long period the industry was conducted along experimental lines, but afterwards developed into a commercial enterprise. It progressed rapidly until 1911 when the restrictions on emigration imposed by the Indian Government began seriously to hamper the industry by taking away a source of cheap and plentiful labour. Although there is at present approximately £350,000 invested in this industry, the tendency is to abandon the cultivation of tea in favour of sugar.

The production of sugar cane for the manufacture of sugar is confined to Natal and Zululand, although its culture can be carried on in Rhodesia and over a great part of Portuguese East Africa. The total area under cultivation in 1916-17 was 163,000 acres. The quantity produced was, however, insufficient to meet the requirements of the country.

Although favoured with unusual conditions tending to promote its expansion, South Africa's fruit industry is still in its infancy. However, the magnitude which it may eventually assume can be gauged to some extent by taking into consideration the large number of varieties of fruit which experiments have already proved can be successfully produced upon a commercial scale, the long season of growth which is opposite to that of the northern hemisphere, the geographical position of South Africa with respect to the European markets, and the highly developed steamship service existing between the Union and the British Isles and Europe. The principal fruits grown upon a commercial scale are apples, apricots, avocado pears, bananas, cherries, custard apples, Cape gooseberries, figs, granadillas, grapefruit, grapes, guavas, lemons, limes, litchis, mangoes, olives, oranges, pawpaws, peaches, pears, pineapples, plums, quinces, and strawberries.

The consumption of fruit is very large in in the Union, especially in the mining districts, and the export trade is increasing.

The seasons being reversed, the markets of Europe and North America are available to exporters of South African fruit. Fresh fruit is plentiful in the Union when it is almost

unprocurable in England and at a period of the year when competition is at a minimum in the United States. For almost half of the year South Africa has no nearer competitor in the European market than the Australasian Colonies and certain parts of South America In addition, it is connected with the United Kingdom by a regular steamship line, besides being served by less regular sailings The arrival of fruit on the European market in first-class condition is rendered possible by the provision of cool chambers, suitable for fruit traffic.

That South African fruit can be placed upon the European and North American markets is evident from the following dates of ripening, arranged according to seasons, which are not so clearly defined in the Union as in the United States:

November —Figs, apricots, strawberries, peaches, pineapples, bananas, and pawpaws

December.—Apricots, plums, peaches, strawberries, pineapples, bananas, and pawpaws

January.—Strawberries, peaches, plums, grapes, early pears, apples, pineapples, bananas, pawpaws, pears, and mangoes

February.—Peaches, nectarines, grapes, plums, melons, pineapples, bananas, and mangoes

March and April.—Grapes, late apples, pears, peaches, and pawpaws

May and June —Guavas, pineapples, bananas, Cape gooseberries, oranges, naartjes, lemons, avocados, walnuts, and chestnuts.

July to October --Oranges, lemons, naartjes, grapefruit, limes, loquats, pineapples, and bananas

The production of citrus fruits was in the past confined to comparatively small areas and the total income derived annually therefrom was of slight moment, but in recent years new and increasing interest in this industry has been awakened, and now it promises to assume far-reaching importance. The area of land on which citrus fruit will thrive is large, and for this reason, as well as on account of the favourable conditions tending to promote the development of this industry, an increasing amount of capital is being invested in citrus and other non-deciduous fruit plantations.

The orange is the principal citrus fruit cultivated in South Africa It can be grown in every Province of the Union and practically throughout Rhodesia, although no large groves yet exist in the Orange Free State, notwithstanding the name. Many different varieties of oranges are grown, but the tendency is to restrict cultivation to those which are suitable for the export trade. Seedlings, which represent approximately 75 per cent. of the bearing trees in the country, are found all over South Africa

Naartjes (mandarins) also thrive in the favourable climate of the Union, but this class of fruit has not yet proved sufficiently popular in the European markets to warrant extensive cultivation Grapefruit has never been grown on a large scale, and as an export fruit lemons have not succeeded in competing with the product of Southern Europe and California. Other citrus fruits are the lime, cumquat, shaddock, and citron.

The culture of the mango in South Africa is comparatively of recent origin and hence the South African export trade in this fruit is inconsiderable. The mango is grown to greater perfection in the Barberton district of the Transvaal than in any other part of the Union. However, Natal produces mangoes in greater quantity than the Transvaal, although the fruit is frequently of low grade.

Much more profitable is the growing of pawpaws, which are highly appreciated throughout South Africa This fruit, which is among the most healthful to eat, is very delicate, and conditions at the present are such as to preclude any large amount of exports.

As an ornamental plant or adjunct to the garden for the sake of its foliage the banana is found over a great part of South Africa, but it is produced commercially in Natal only Even in that Province the banana is not extensively cultivated, and the total production barely meets the requirements of the Union A fruit greatly appreciated but produced upon a small scale solely for domestic consumption is the avocado, or alligator pear, which also is grown in Natal and the warmer parts of the Transvaal

Like other fruits of a more or less tropical character the pineapple thrives in Natal, the Eastern Province of the Cape of Good Hope, and certain parts of the Transvaal, but in the Transvaal irrigation is generally employed in order to obtain perfection inasmuch as the clear and dry climate does not contain sufficient moisture to enable the pine to make successful growth. All that is conducive to the production of pines of the finest quality, as regards both soil and atmospheric conditions, is to be found in the lower Albany district. Here more planting has taken place in recent years than in any other part of South Africa, and this district is the largest producing area in the Union. That the pineapple industry bids fair to develop upon a sufficiently large scale to permit of a good-sized export trade being built up is evident from the new capital seeking this outlet. One company acquired recently a large estate for the purpose of growing pineapples and other fruits.

Apples of good quality are grown in many parts of the Union, the chief centres of culture being the Eastern and Western Provinces of the Cape, the Orange Free State, Transvaal, and the highlands of Natal. On the high, cold veld of the Orange Free State there are some of the largest and best developed orchards in South Africa. The fruit is not only of good size and appearance, but possesses an excellent

flavour. The quality of the fruit grown in the Transvaal, which is similar to the Orange Free State as regards altitude and climate, is equally good, while the Western Province of the Cape possesses the oldest trees in the Union South African apples make an excellent dried fruit, and this phase of the industry is gradually assuming more importance

The pear is more extensively planted in the Western Province of the Cape than in any other part of South Africa. It is the leading export fruit and in flavour, size, and appearance is highly regarded upon the European markets The Asiatic type of pear also grows widely in the hotter parts of the country, but it is not so popular on account of inferiority in flavour and texture

Peaches of many varieties are to be found all over South Africa, but, as in the case of pears, climatic conditions, dependent principally upon altitude, determine the type of peach to be cultivated The high veld is suitable for peaches commonly grown in Europe and North America; while the low and bush veld is adapted to peaches of Chinese origin The Western Province is probably the largest producing area, but the peaches grown on the high veld are superior in quality This is notably the case in respect of the vicinity of Johannesburg, where peaches of almost unsurpassed excellence are grown. Peaches of good quality always command high prices in the local market, and to some extent they enter into the supply of both canned and dried fruit

Nectarines grow best on the high plateaus of the interior, while apricots attain the greatest perfection near the sea The Western Province is the most important producing district for both fruits The fig not only thrives in the Cape Province, but also does exceedingly well in the Transvaal, where its cultivation upon a commercial scale is very limited On the other hand, there is a fairly large trade in plums, especially in the Western Province, which is the leading centre for the production of deciduous fruit. The type of plum which flourishes best in South Africa is of Japanese origin, the export trade being almost wholly confined to this class.

The grape vine was introduced into South Africa as early as 1653, and to-day it is found growing all over the Union Certain districts are, however, better adapted than others to the cultivation of the vine owing to climatic influences, and, in consequence, the chief centre of culture can be given as lying between 33° and 34° south latitude. The yield of the vine is probably as high in South Africa as in any country. Besides serving as a table fruit for both domestic and foreign consumption, grapes are used to a very large extent in the local manufacture of wine and brandy.

Of the berry and bush fruits, the strawberry, raspberry, loganberry, and "Cape" gooseberry grow in abundance. They are cultivated chiefly for the purpose of supplying the local demand and to a smaller extent for canning and the making of jam.

The wild olive is found throughout South Africa, but all attempts to establish a successful industry have failed so far The principal drawback to the industry is said to be the presence of the "olive fly," an insect well known to the olive-growing countries of Europe. While this is a deterring factor in the development of the industry in South Africa it does not by any means preclude the successful growing of olives in that country

RESOURCES AND TRADE OF THE SANTA CRUZ DISTRICT OF BOLIVIA.

The Department of Santa Cruz, possessing a total area between 367,000 and 376,000 square kilometres, is situated in Eastern Bolivia. It is bounded on the west by the Departments of Cochabamba and Chuquisaca, on the north by the Department of El Beni, merges on the south into the unexplored plains of the Gran Chaco, and is bordered on the east by the great Brazilian State of Matto Grosso.

The Department is divided into the seven Provinces of Cercado, Sara, Cordillera, Vallegrande, Nuflo de Chavez, Velasco and Chiquitos. The provinces of Sara, Cercado, Nuflo de Chavez, and Velasco consist largely of plains that are an extension of those of the Beni, and this area of low country is connected with the plains of the Province of Cordillera by the belt of the Monte Grande, which lies between the Guapay and the San Miguel to the east of Santa Cruz. The plains of the Province of Cordillera are in turn only a continuation of the vast "llanuras" of the Chaco.

Though most of the Department lies outside the region of the Andes, the Province of Vallegrande is a rough district lying among precipitous ranges, which rise in places to a height of nearly 10,000 feet. In the eastern parts of the Department a broken series of low hills run in a south-easterly direction across the Chiquitos country from the region of the Guarayos to the Rio Paraguay below Corumba. There are many valleys and pockets among these hills with considerable extensions of agricultural and pasture lands.

Most of the area of the Department is drained by tributaries of the Amazon system. The eastern section is drained by affluents of the Paraguay, which runs close to the frontier. The Rio del Curiche Grande, a tributary of the Paraguay, separates the department from Brazil for some distance above Puerto Suarez. In the south-western part of the Department the mysterious Rio Parapiti crosses the province of Cordillera, where through parts of its course it spreads out across the plains in the wide "Cañados" or marshes of Isozo, and finally disappears in the sands of the Chaco.

The climate of the Santa Cruz region varies from sub-tropical to tropical, the climatic gradations depending on the diversity of altitude and of latitude There is little rainfall between July and November, but there are heavy rains from November to March, and rain may also fall in April, May and June. The rainfall is heavier in the low-lying Provinces of Cercado, Sara, Nuflo de Chavez, and Velasco than in those of Vallegrande and Cordillera and in most of Chiquitos, though there are occasional torrential rains in the outlying ranges of the Andes and in the hill country of Chiquitos. In some years there is a dearth of rain in Cordillera, especially in the parts bordering Chaco; however, there is usually a plentiful supply of sub-surface water which could be easily reached with artesian wells.

The winter coincides with the time of least rainfall, and the summer is the season of heaviest rainfall The average yearly temperature at Santa Cruz is about 25° C The winter temperature generally ranges between 11° and 22°, and the summer temperature usually varies from 25° to 35°

In most districts the climate is notably healthful, though the habits of the natives are extremely insanitary. Malaria is prevalent in certain parts, as in some of the Chiquitos valleys, and there have been occasional outbreaks of dysentery and smallpox, but in general health conditions compare very favourably with those any part of South America Some districts, as about Santiago de Chiquitos, have an almost ideal climate

The city of Santa Cruz, which was built in 1560, is the political capital and commercial centre of the Department It lies about 3 kilometres from the Rio Pirai at an altitude of 1,380 feet above the sea level, and is situated in the midst of a great plain, across which a network of roads leads in every direction In 1900 Santa Cruz had a population of 18,335 people, which at present probably amounts to 20,000.

Most of the construction work in the City is of plaster and wood, and the houses generally have porticoes in front for protection against the heat The streets are unpaved and deep in sand when they are not flooded by torrential rains which fall during the summer, and are lighted by oil lamps. When the resources of the surrounding region are developed Santa Cruz will undoubtedly be one of the most important inland cities of South America

According to a report by the United States Trade Commissioner, in Bolivia, from which the following particulars are extracted, the problem of communication with the outside world is one of prime importance to the economic life of this remote part of the Republic. At present there are four principal trade routes from Santa Cruz, leading respectively, to the north, the east, the south, and the west. To the Beni there is a cart track as far as Cuatro Ojos on the Pirai during the rainy season, and as far as Las Juntas or Puerto Velarde, at the junction of the Pirai and Grande, during the dry season The distance from Santa Cruz to Cuatro Ojos is about 90 miles, and thence to Puerto Velarde is another 30 miles. In the wet season the road is very bad in the forest of Cuatro Ojos for a stretch of several leagues, and beyond that it is a veritable bog. Cuatro Ojos and Puerto Velaide are, respectively, the limits of launch navigation on the Mamore system during the wet and dry seasons. Launches ply down the Mamore by Trinidad to the terminus of the railway at Guajaramirim

This route is undoubtedly destined to be of increasing importance to the Santa Cruz country and is at present the only practicable road for the importation of bulky merchandise Pieces weighing 2,000 to 2,500 pounds, and probably more, could be brought in by this route. Goods can be shipped directly to Santa Cruz by consigning to the Madeira-Mamore Railway Co at Para or Manaos, or to the Amazon Steam Navigation Co, at Para. The Madeira-Mamore interests now have an agent in Santa Cruz Such consignments should be marked "Para despachar a Santa Cruz, Bolivia."

One of the most famous routes in Bolivia is the old cart road between Santa Cruz and Puerto Suarez, which was laid out by Suarez Arana between 1874 and 1879, and which connects the interior of the Republic with the Paraguay River. This road, between 690 and 700 kilometres long (1 kilometre = 0 621 mile), crosses the Rio Grande a few miles out of Santa Cruz and then disappears into the wilderness of the Monte Grande For about 135 kilometres it is a narrow track cut through the forest, with four pickets of soldiers at intervals of a day's ride. After leaving the Monte Grande the road skirts the marshy Lake Concepcion and then passes through San Jose, the capital of the Province of Chiquitos Thence it leads below Santiago and by the villaige of Santa Ana to Puerto Suarez on the Laguna de Caceres, from which communication is had by a narrow channel with the Rio Paraguay.

During most of the year the lagoon, though large in extent, is too shallow to admit vessels of the draft which ply between the River plate and Corumba At such times it is navigable only for launches drawing from 1 to 2 feet of water, and the channel is often obstructed by great floating beds of weeds. It is sometimes necessary to unload goods on to carts at Puerto Sucre, between Corumba and Puerto Suarez, for transportation to the latter point. For probably two months of the year, when the Paraguay is at its height, steamers which reach Corumba and which draw 5 or 6 feet of water are able to enter the Laguna de Caceres and discharge their cargo at Puerto Suarez.

The route between Corumba and Puerto Suarez followed by the launches is about 10 miles in length.

Long stretches of the eastern road, especially across the low country between the last of the Chiquitos hills at the Carmen ranch and Puerto Suarez, are flooded during the rainy season and converted into almost impassable bogs for considerable distances. Myriads of mosquitoes and other small but extremely annoying insects torment the traveller who makes this trip in the rainy season. On the other hand, during the dry season, which is at its height in September and October, there is a serious scarcity of water over this stage of the road, and travellers are dependent for water for themselves and their pack animals on the precarious supply which they may encounter in the water holes at intervals of many leagues along the roads.

The traffic over this road is by means of mules, oxcarts, and bullocks. Mules, which are often difficult to obtain, reach Santa Cruz in about three weeks from Puerto Suarez. Oxcarts drawn by five or six yoke of oxen cover the distance in from 35 to 40 days when the road is at its best, but after the annual rains have begun they may require from 6 to 10 months for the journey, being held up for weeks at a time by swamps and swollen rivers. Considerable travelling is also done on the backs of bullocks, whose splay feet prevent them from miring in the deep mud and sand through which much of the road lies.

This road has lost most of its importance as a route for the importation of foreign goods into Santa Cruz, and practically all the merchandise sent out of Puerto Suarez is distributed among the towns of the intervening region, such as Santiago and San Jose, or is diverted from the main road into the country to the north.

The road from Santa Cruz into Argentina leads south and to the east of the last foothills of the Andes, to which it runs roughly parallel, and reaches the frontier at Yacuiba, thence continuing to the terminus of the Argentine Central Northern Railway at Embarcacion, a distance of 879 kilometres from Santa Cruz. Most of the traffic over this road is by means of mules, though oxcarts are also used for some classes of merchandise. At certain times of the year there is a lack of water over some of the southern stretches.

The most important road from Santa Cruz is that which connects with the plateau and the Pacific by way of Cochabamba. This road passes through the towns of Samaipata, Pampagrande, Chilon, Totora and Arani, and thence across the valley of Cochabamba to the end of the railway from Oruro at Cochabamba. From Santa Cruz to Totora the road can be used only by mules, but from Totora to Arani is open for automobile traffic during the dry season. From Arani into Cochabamba, a distance of 66 kilometres, there are daily trains over the narrow-gauge railway of the Empresa Luz y Fuerza Electrica Cochabamba. However, mule trains between Santa Cruz and Cochabamba do not break their journey between these two points. The total distance of about 470 kilometres is covered by mule in from 12 days to 2 weeks, and Totora can be reached from Santa Cruz in 9 or 10 days. Each mule will carry about 8 arrobas, equivalent to about 200 pounds, and the charge for freight is from 45 to 60 bolivianos per mule. From the edge of the plain, a few leagues outside of Santa Cruz, nearly to Arani, the course of the road is through a rugged mountain region, some of the roughest country lying among the last Andean ranges in the vicinity of Samaipata. There are several precipitous climbs and descents, and travelling is difficult during the rainy season, when the track is muddy and slippery and the streams are full.

There have been several projects for giving the Santa Cruz region a railway outlet to the Paraguay River. In 1889 an English firm proposed to the Bolivian Government to build a railway from Puerto Pacheco to Sucre, and another from the Laguna de Gaiba into the Itenez country, but nothing came of these proposals. In 1900 a Belgian company presented proposals for a line from Bahia Negra to Santa Cruz, including an ambitious programme for the development of eastern Bolivia. The concession granted to this company expired in 1914, similar proposals having been made meanwhile by Italo Argentine interests. Recently certain Brazilian interests have made overtures to the Bolivian Government for the prolongation of the North-western Railway of Brazil from Porto Esperança by Corumba and Puerto Suarez to Santa Cruz. Construction of such a line should be easy, as grades would be negligible and in no part would there be required cuts or fills of over 5 metres (1 metre = 3.28 feet) in depth.

There have also been several projects for a railway line to connect Santa Cruz via Yacuiba with the Argentine system of lines. At present a project is on foot for the building of a railway from Sucre to the lower Pilcomayo with an outlet to the Rio Paraguay at Formosa over the Argentine State Railway, which is being extended north-west to Embarcacion. This project is connected with the plans of American interests for the development of the oil fields in the Lagunillas district.

Alternative destinations for a railway from Santa Cruz to the plateau are Cochabamba and Sucre. General opinion favours the route from Cochabamba. The further development of eastern Bolivia is absolutely dependent on the establishment of better communications with the outside world. This project would afford not only a more satisfactory outlet for the products of the Santa Cruz region, to the markets of the more thickly populated plateau, but access to foreign markets as well.

The building of railway lines from Cochabamba and the Paraguay River would give the needed impulse to the great industrial possibilities of the eastern part of the country in such products as sugar, cotton, cattle, tobacco, petroleum, lumber and other products Moreover, it would supply the necessary link for the completion of a trans-continental line from Santos to Arica A thorough study of the Cochabamba-Totora route was recently completed by an American engineer; and a Government commission, headed by an Argentine engineer, was engaged on similar surveys It is estimated that, because of the difficult nature of the country to be traversed, the construction of a Cochabamba-Santa Cruz line would cost between £8,000,000 and £10,000,000

In spite of the great natural advantages of this region—the vast extent of level and fertile land and a highly favourable climate—agricultural development has probably fallen off 25 per cent during the past two decades. This decline is due largely to the fact that new lines of transportation have been pushed in from the outside toward the Santa Cruz country, tapping fields that were formerly markets for the consumption of the products of that region.

The Santa Cruz plains are excellently adapted to the raising of sugar cane, which is generally planted in November and cut in May, the same plants being worked for three or four years The sugar produced is of fairly good quality, in spite of the antiquated methods used in refining it Most of the industry is carried on by small crushing mills operated by ox power, and the sugar is whitened by means of mud

The actual production of cotton represents only a very small proportion of the possibilities of the region in this product Two varieties of plant are commonly grown One of these is ready for picking in five or six months, with a fibre from 4 to 5 centimetres long The other is a native cotton bush or tree, which grows to a height of 6 feet or more and bears for about 20 years This plant produces from 6 to 8 pounds of cotton twice a year, and an acre will produce about three 500-pound bales of seeded cotton.

Rice is an important article of local diet, and is widely grown in the lower-lying districts of the Department. Coffee of prime quality is grown about San Jose and Santiago in Chiquitos, though in limited quantities. It is also produced in other parts of the Department.

Though formerly important in some districts, as in Vallegrande, the cultivation of tobacco has declined Growers claim that the Government monopoly has discouraged the industry, though some tobacco is still made up into cigarettes at Vallegrande. In Chiquitos three crops of tobacco are produced from the same root.

Wheat, barley, and potatoes are grown in Vallegrande. Maize does well and is widely grown throughout the Department. A good grade of cacao is produced in the north-eastern section of the Department, and yerba maté has been successfully grown in Chiquitos and Velasco. A large variety of fruits, including bananas, oranges, pineapples, melons, lemons, alligator pears, grapes, figs, and pomegranates flourish in this part of Bolivia. Oranges and lemons grow wild, melons yield practically the entire year in Chiquitos, and excellent vegetables can be raised almost everywhere Yuca or mandioca, especially, constitutes a very important item of diet among the common people of the region.

Stock raising is at present the most important industry of the Department. In the plains country there are wide areas of lands covered with high grass, on which large herds of cattle feed. In the Chiquitos region herds are smaller, but the pasture lands are sufficient to accommodate a far greater number of cattle. The Beni and the northern Provinces of Argentina are the only outside markets for the cattle of Santa Cruz, and it is the limited capacity of this market which constitutes the principal obstacle to the expansion of the industry. It is impracticable to drive cattle in any considerable numbers over the mountains to Cochabamba Large numbers of hides, however, are sent to Sucre and Cochabamba as sole leather.

The Department is excellently adapted to the raising of hogs and much of it is well suited to sheep and goats Existing conditions are not favourable for horses and mules because of the wide prevalence of the "mal de cadera" or "peste de lomo," which attacks the spinal cord, generally with fatal results

The basin of the Quisere River passes through the three auriferous regions of Concepcion, San Javier, and San Rafael The placer beds of San Javier were worked during the Jesuit régime, as were also the deposits of the San Simon district in the Itenez country The Rio San Miguel which has a quartz bed and skirts some low mountains where gold is known to occur, possesses alluvial deposits which could be worked with dredges for part of the year. Little has been done of recent years to exploit the gold resources of the three north-eastern Provinces where the metal is found. Silver is known to exist in the mountains of Colchis, in Chiquitos, and iron and quicksilver have been found in Crodillera and Vallegrande. Salt beds in the northern Chaco, to the south of San Jose de Chiquitos, are being worked at present.

The natives have long baled oil from seepages in the region. Two classes of oil are brought into Santa Cruz from two different localities about 60 miles apart, and not connected by a range of mountains. One series of seepages is located in the canyon of Espejos about 15

miles from Santa Cruz, and a few miles to the north of the Cochabamba road, and the other is located in a canyon in the mountains near Buena Vista, about 50 miles from Santa Cruz These oils have a specific gravity of 48° Baumé, and yield about 78 per cent. of burning oils

There are probably over 60,000 square miles of forest in the Department of Santa Cruz Scattered over the great plain about Santa Cruz are isolated patches of woodland and in parts of Chiquitos and Cordillera there are wide expanses of scrub forest. The Monte Grande east of Santa Cruz is a vast forest wilderness, and across the northern part of the Department from Sara east across Nuflo de Chavez and Velasco to the Brazilian border there stretches an immense area of real tropical forest. These forests contain a great variety of valuable trees, among which are found mahogany, ebony, quebracho, lapacho, jacarandá, curupay, walnut, lignum vitæ, Spanish cedar, and the giant carob Some of these are cabinet and construction woods; others, like quebracho and curupay, are valuable for their large tannin content. In spite of the timber wealth of the Department, lumbering operations are very limited, and sawmills are small and few in number Axes, adzes, and cross-cut saws are the principal tools used in lumbering.

The extraction of rubber is an important industry in the northern section of the Department; part of the product is taken out through Puerto Suarez, but most of it is exported by the Itenez and Madeira.

The production of cane alcohol is the most important manufacturing industry of the region In 1918 there were produced in the entire Department, 352,058 litres of cane alcohol. and 79,923 litres of cane brandy. There are 241 establishments producing alcohol of which 113 are in the Province of Cercada.

There are also tanneries, saddleries, cigarette factories, ice factories, sugar refineries, and sawmills, most of which operate on a very small scale. Rubber ponchos and rubber shoes are made in Velasco and Nuflo de Chavez, but the industry is of little importance

A condition of general depression and stagnation in business exists in the Santa Cruz country, and there can be little hope of any radical improvement until that region has better connections with the outside world Only the building of railways from either direction can give it the prosperity to which its natural possibilities entitle it.

The principal goods in demand are cottons, canned goods, general hardware, such as axes, saws, and cane knives, carpenters' tools, hats, and general wearing apparel of a cheap grade; prepared medicines, tin and galvanized wares, rifles, light ploughs, and gunsmiths' and machinists' tools. There is also a need for small sugar-making apparatus, mills for husking rice, and light sawmill equipment. It should be remembered that all machinery sent into the Santa Cruz country must be transported from river or railhead to its destination by means of oxcarts, and that, moreover, such merchandise cannot be transported over the Cochabamba route, which is used only by mules

CORRESPONDENCE.

SURFACE COMBUSTION

I spoke from "information received," and am glad to know wrongly; but I am not sorry that I did so, as Professor Bone, in consequence, has the opportunity to make known that his remarkable burner has even been improved and that its use is being developed. I assume a separate supply of air under pressure is still indispensable. If the burner can be at all generally applied, it may be the salvation of the kitchen and make possible the return to rational healthy cooking by radiant heat. I should like once more to realise a fond memory of my youth --to enjoy the creamy mellowness of the Yorkshire pudding begun in the oven, but finished before the fire and anointed with the juices and flavours from the Jack-turned, roasting—not baking—joint above Prof. Bone has made a great beginning: I would urge him to leave Royal Society academic research to others and apply his inventive powers to the development of an efficient rational system of household cooking by gas We are making no proper use of our "science" to-day

HENRY E. ARMSTRONG.

GENERAL NOTES.

ROOFING-TILES IN EAST AFRICA.—The provision of roofing material for buildings in the tropics is often a matter of difficulty. Corrugated iron is largely employed, but it is frequently very costly, and, moreover, tends to make the building unbearably hot In several countries in Africa it has been suggested that roofing tiles should be made locally, and search has been made for suitable materials Specimens of clay and sand, collected in Uganda, and of clay and diatomite from Kenya Colony, have recently been examined at the Imperial Institute in order to ascertain their possibilities in this direction, and the results of the investigation are given in the current number of the Bulletin of the Imperial Institute. It is shown that tiles of good quality can be made with a suitable mixture of the clays and sand from Uganda, whilst good tiles can also be made from mixtures of the washed clays with "grog," i.e., clay which has been burnt and finely ground. The clays from Kenya Colony were also found to be suitable for making roofing tiles. The results obtained with the infusorial

earth or diatomite (which contained a certain proportion of clay) are of special interest, as this material, which does not appear to have been employed previously for the purpose, furnished tiles which were much lighter than ordinary roofing tiles, which is a great advantage. There are extensive deposits of infusorial earth in Kenya, not at present worked.

DAVID HUGHES'S WIRELESS TELEGRAPHY APPARATUS.—In a letter published in the *Times* of March 28th, Mr A A Campbell Swinton, F R S., writes:—A search, suggested by myself to Colonel H. G Lyons, of the Science Museum, made amongst the contents of a room full of Hughes's personal effects that for the last 20 years have been stored in a furniture repository in London, has revealed the existence of a number of electrical instruments, comprising the original first microphones invented by Hughes, and the actual apparatus with which he made his early wireless experiments, all obviously constructed with his own hands. The several instruments can easily be identified by the illustrated descriptions in the notebooks, and we thus have a collection of great historical and scientific interest, which, through the generosity of the Hughes trustees, has been presented to the Science Museum in South Kensington, where it will shortly be on public view."

INSTITUTE OF TRANSPORT.—The Council of the Institute of Transport announces that it will undertake suitably to celebrate principal events in transport history, and, in this connection, will arrange for celebrations of the centenaries of the opening of the Stockton and Darlington Railway in 1825, and of the Locomotive Trials at Rainhill in 1829, at which latter the famous engine "Rocket," by George Stephenson, established the supremacy of steam engines over the then known method of steam transport, namely, stationary steam engines These celebrations will probably be held in connection with the annual Congresses of the Institute in the years in question, and a centre in the vicinity of Stockton and Darlington and of Rainhill will be selected for the purpose and appropriate methods devised for adequately celebrating these important events

INDIAN LAC, TURPENTINE AND ROSIN.—About 94 per cent of the world's supplies of lac (shellac, etc.) comes from India, the rest from Indo-China and Siam. In spite of this practical monopoly of the trade, the state of the industry in India is not altogether satisfactory. The Special Committee on Gums, Resins, and Essential Oils, of which Sir Harvey Adamson, K.C.S.I., was Chairman,* make various recommendations for improving the present conditions of the industry, for placing the manufacture on a thoroughly efficient basis, and safeguarding the interests of India and the Empire. Although India possesses large areas of pine forests from which turpentine and rosin could be obtained, the country has not hitherto figured among the large producers of these materials, and is still dependent to some extent on foreign countries for its own requirements. The Special Committee consider that every effort should be made to increase the Indian output, and recommendations are made with this end in view. The last section of the publication gives interesting particulars relating to the production of turpentine oil and rosin in India, and the characters of the products obtained from the different Indian pines.

*The Report of the Committee, a new volume in the series of Reports of the Indian Trade Enquiry conducted at the Imperial Institute, has just been published by Mr. John Murray.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, APRIL 10. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. Oldham, "Hints on the Storage of Perishable Produce with Special Reference to Eggs."
Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Mr F. Roberts, "Seven Decisive and Suggestive Scenes in the History of the Secular Contest between Conscience and Power."
Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

TUESDAY, APRIL 11. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. A. Millar, "Galicia and its Petroleum Industry."
Rubber Industry, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir Edgar Walton, "Resources and Advantages of South Africa as a Field for Industrial Development."
British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 3 p.m. Annual General Meeting
Historical Society, 22, Russell Square, W.C., 5 p.m. Mr C. Johnson, "The System of Account of the Wardrobe in the Reign of Edward I."
Sanitary Institute, 90, Buckingham Palace Road, S.W., 5.30 p.m. Sir Henry Tanner, "Economy in Sanitary Appliances and Methods of Drainage."
Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. (1) Captain T. A. Joyce, "The Paquecha of Ancient Peru." (2) Miss A. C. Breton, "Notes on some Peruvian Antiquities."

WEDNESDAY, APRIL 12. Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. (1) Mr. F. W. Edwards, "Oligocene Mosquitoes in the British Museum with a Summary of our present Knowledge concerning Fossil Culicidæ." (2) Prof A. C. Seward, "On a Collection of Carboniferous Plants from Peru." (3) Miss M. E. J. Chandler, "The Geological History of the Genus *Stratiotes*: an Account of the Evolutionary Changes which have occurred within the Genus during the Tertiary and Quaternary Eras."
Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.
Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Professorial Lecture.
Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Mr. A. F. Evans, "Marine Engine Design as affected by Lifeboat Conditions."

THURSDAY, APRIL 13. Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m.

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FRIDAY, APRIL 14, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 5th, 1922; LORD HEADLEY, M.Inst.C.E.I., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Dawson, Frederick Lawrence, Pyapon, Burma.
Risdon, Philip James, London and Hove, Sussex.

The following candidates were balloted for and duly elected Fellows of the Society:—

Jackson, Miss Frances Agnes, Camberley.
Pe, Maung Hla, M.L.C., Rangoon, Burma.
Sarkar, M. K., Calcutta, India.
Smith, D. Curle, M.I.E.E., Kalgoorlie, W. Australia.

A paper on "Coast Erosion and its Prevention" was read by Professor Ernest R. Matthews, Assoc. M.Inst.C.E., F.R.S.E., F.G.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

FIFTEENTH ORDINARY MEETING

WEDNESDAY, MARCH 8TH, 1922.

MR. JOHN MURRAY, M.P., in the chair.

THE CHAIRMAN, in calling on the lecturer to read his paper, said the subject with which it dealt had been much before the public of late, and especially during the last two years. The history of trade unionism was not a long one, but the unions were of great extent and very great power at the present time. It was perhaps natural that, their growth having been so rapid and their power having become so great, the true theory of trade unions had not yet been arrived at. It seemed to him that the leaders and managers of trade unions, the public at large, and even the House of Commons, should widen and enrich their knowledge of trade unions, and, by so doing, put the unions—he was not speaking disrespectfully—in their place; a moral, constitutional, industrial, legal and practical place. That had not yet been done, but it was a duty for which the lecturer had very special qualifications, as was evident from the long years he had spent in the service of trade unionism and by his conduct in those years of difficulty and danger which had followed the outbreak of the war.

The paper read was :—

THE PROPER FUNCTIONS OF TRADE UNIONS.

By W. A. APPLETON, C.B.E.

A hundred years ago it would have been easier than it is to-day to secure comparative unanimity concerning the proper functions of trade unions. Then, the organisers of the movement had definite, if limited, views, and they were careful to emphasise their attitude towards religion, towards politics and towards the State. In these matters the early part of the 19th century appears to have exhibited a wider tolerance than does the corresponding part of the 20th century.

The workmen in those days were not less religious than their fellows of to-day, and if recollections of one's grandfathers and their contemporaries are of any account, they were not less keen nor less well informed in politics. Their opportunities for reading were less extensive but they appear to have discussed affairs quite as thoroughly, and to have understood them quite as fully as their grandsons. They tried, amongst other things, to keep both religion and politics out of the trade unions they were forming and developing.

It has been said that, having no votes, abstention from class politics can hardly be counted to them for righteousness. Such a contention is neither fair nor accurate.

It would, indeed, be just as fair and just as accurate to argue that because they sought to exclude religious controversies from their branches they were all unbelievers. Perhaps it would be more in harmony with historical data to say that they appreciated the impossibility of developing industrial unity, if, within their organisations, they regularised the discussion of such disintegrating factors as religion and politics.

To-day things are different. The unions are constantly and vehemently invited, at what are alleged to be reputable and representative conferences, to use their industrial power and to jeopardise their industrial interests in the furtherance of such widely differing subjects as the concession of Home Rule to India and the maintenance of despotism in Russia.

The pioneers of trade unionism found themselves opposed to problems as great as, if not greater than, those which face the men who to-day are trying to salvage the movement. They very wisely avoided undue handicaps because their tasks were already onerous enough. They were faced with extraordinary changes in the methods of production and extraordinary aversions on the part of manufacturers to any assumption of responsibility for the physical and social welfare of the men and women whose status the altered methods endangered. Mechanical power was overshadowing man power; the factory was taking the place of the workshop; the free craftsman, owning his own tools, purchasing his raw materials, and selling his products directly to the consumer, was becoming more and more an attendant upon power-driven machinery, and the servant of men who owned the machines. New industrial relationships were being created, and with them the necessity for new methods of protecting from undue exploitation the workman whose willing skill and capacity enabled him to meet the requirements of the industrial overlords.

It was no use arguing the desirability, or the undesirability, of these changes from individual to collective production. They were there, and the inevitability of their development was obvious. Human nature being what it was in the days of Cain and Abel, and what it is to-day, it became necessary to restore some equilibrium by the provision of machinery for securing the recognition of industrial rights, the highest possible payment for industrial services, and the enforcement of collective, as against individual, bargaining. These were then assumed to be the proper functions of the original trade unions.

They proposed to give effect to these functions by negotiation and mutual agreement between the interests involved where this was permissible or possible. Failing this kind of arrangement, they were prepared to embark upon industrial warfare and to force what they considered to be their just demands by withdrawals of labour. At one time it was most common to withdraw only the labour involved. Then it became the practice to withdraw related labour, that is, men in the same employment, or the same industry, and, latterly, there has been the demand, and the attempt, to paralyse, not only industries concerned, but all industries. The first withdrawal of labour affects only the firm or firms actually and directly in dispute: the second involves, irrespective of location or association with the causes of dispute, all the firms in the industry; while the third involves the whole community. In any case, there is suffering and loss, but when the latter form of withdrawal is attempted, loss develops into disaster.

The strike against the bad employer invites and secures public sympathy. A strike against the good employer, for the purpose of coercing the bad one, may be condoned on the ground of tactics; but a strike which embroils all industries and all public services involves all in misery, and is condemned by all except the fanatics who propose it, or the scamps who hope to profit by it.

Elsewhere I have described a trade union as an organisation for the betterment of wages, hours and working conditions of persons engaged on similar materials, using similar tools, and producing similar results, and I should say that to-day their proper functions embraced every problem connected with, or arising out of, employment and unemployment, and out of trade and commerce, in so far as these affect employment.

Amongst these problems would be those affecting wages, hours, conditions under which employment is provided, safe-guards against industrial disease and accident, compensation where disease or accident results, and provision against unemployment. I should consider the unions were

justified in using their power through any of the political parties, to remove, or to prevent, the imposition of restrictions that hampered manufacture or commerce, and, by so doing, developed unemployment.

Knowing something of trade union opinion and practice, I should not include amongst functions which they can satisfactorily perform, those which cover the provision of capital, the discovery and exploitation of markets or the actual direction of business.

If work is intelligible effort intelligently applied then wages may be described as the reward of those who create value by work. In discussing the problem of wages, it is desirable to start by recognising that work, qua work, has not sufficient value to justify claims for wages. It may provide the exercise necessary to the maintenance of health, but it has no more moral nor financial value than the treadmill.

There is much foolishness talked about the provision of work, particularly the State provision of what is termed "useful" work. In a country dependent, as is Britain, upon outside sources for much of her raw material and for three-fourths of her food, the only useful work is that which produces commodities, or provides services, which can be exchanged in overseas markets for raw materials and food. Repairing roads, reclaiming foreshores, and planting forests is work which has disciplinary and internal value, but it only affects the external purchasing power of the country to a very limited extent.

Whatever value is thus created, accrues slowly and benefits future generations more than existing ones.

In proposing work of this kind it is always advisable to consider carefully the national circumstances at the time when the necessary capital expenditure is demanded, together with the period which must elapse before reasonable returns can be expected. Unless this is done the general circumstances may be made worse instead of better. It would, indeed, be foolish to spend money on forests, which for many years can give no exchangeable value, when the money is needed for machines and commodities which promise an immediate and a recurring return.

In describing wages as the reward of those who create value by work, the trade unionist is not likely to overlook the fact that the reward is sometimes inadequate, nor do I personally make the mistake of assuming that monetary return represents the whole of the reward. Every workman who has the instincts of the artist, and there are hundreds of thousands of such, knows that there is an important form of return which finds expression in the personal satisfaction and happiness which accompanies the sense of work well done and things created.

The thoughtful trade unionist will differentiate also between nominal and actual wages, between money received and purchasing power conferred, between the unit of measurement and the useable and consumable things for which this unit can be exchanged. These latter things are indeed the real wages. All other things—gold, notes or cheques are just representatives.

The right to discuss a subject involves the duty of trying to understand it, and no conscientious trade unionist should attempt to negotiate wages questions without having tried to understand the factors that govern wages. Opinions will, necessarily, differ as to which are the most important factors. Personally, I should place them in the following order :—

(1) Those involving the workman's capacity, such as physique and general health ; knowledge of tools and processes ; period of training for specific work ; measure of intelligence and good-will.

(2) Those affecting the personality of the manufacturer, in which I should include general knowledge, industrial and commercial experience, initiative, adaptability, enterprise, courage and the ownership or possession of capital.

(3) The accessibility and cost of necessary raw materials.

(4) The accessibility of markets, together with the transport facilities and costs.

(5) The amenability of markets, particularly overseas markets, to the conditions governing production at its centre. This would include questions relating to the nature of the commodities required, their quality, the price likely to be obtained, and the profit likely to be earned.

(6) The inviolability or otherwise of contracts of service entered into between workmen and employers, particularly where the observances of these contracts affect continuity of production and certainty of delivery. In this connection it is important to weigh the effect of the necessity for inserting clauses safeguarding the manu

facturer, or the contractor against losses arising out of sudden strikes. It is obvious that countries inserting these clauses incur very serious handicap as against countries where they are unknown or not observable. Such reservations indicate a liability which may not mature, but which always threatens and which frightens prospective customers.

(7) The facilities which exist for the fullest use of fixed capital, such as buildings, machinery, railways, docks and ships.

(8) Extraneous factors such as taxes and rates. As these must be charged to productive costs, their weight and their incidence demand the gravest consideration.

(9) Political interferences which limit the use of fixed capital, or check enterprise, and by so doing, increase costs of production or distribution. A good example of this kind of interference is the legislation which permits the pork butcher to sell cooked chops after seven o'clock in the evening, but which fines him for selling uncooked ones during the same hours. The absurdity of such legislation is obvious, but no party in Parliament has made effective efforts to repeal it.

In addition to the factors which govern the rise and fall of money wages, the trade unionist is justified in defining his attitude towards those which reduce real wages. Amongst these, he will find none more pernicious than the subsidies which have been given to munition workers, to building, to railways and to mines. Perhaps nothing in recent years has so appeared to humiliate Parliament as the spectacle of one Party foolishly demanding subsidies, and another Party weakly conceding them. These subsidies, by creating artificial purchasing power without providing contemporaneous and equivalent production of commodities, have increased prices enormously, and to the extent of this increase they have seriously penalised less fortunate sections of the community.

It is common amongst some who have attached themselves to the trade union movement to declaim against what they are pleased to call the moral degradation of receiving wages. I have been a wage earner all my life and can honestly declare that I have never felt this degradation. Wages, whether they are paid in cash under capitalism, or in kind, under socialism, carry neither moral nor social stigma, except to those who haven't tried to earn them.

After wages, the trade unions are justified in pressing their right to intervene where hours of employment are too long. The forty-eight hour week has been their ideal, and they regard its maintenance as a cardinal matter of policy. There are, however, occupations in which eight hours would not only be excessive, but impossible. On the other hand, it is argued that there may be occupations so little exhaustive of mental or physical fibre that eight hours appear, by comparison, too little.

Under socialism, if its protagonists are rightly understood, attempts might be made to secure uniformity of effort but not uniformity in period of time over which the effort should be spread. I have always understood that "from each according to his capacities" does not necessarily signify from each according to the time occupied. I admit the difficulty of meeting the assertion that there is no fairness in the demand that a locomotive engine driver, or a signalman in a busy junction box, shall work the same hours as the porter in the wayside station whose most exhaustive work is that of waiting for the trains that seldom come.

There are indoor and outdoor occupations, and in the former the unions should have no difficulty in realising their ideals. Most of the latter, however, are governed by the elements. In these outdoor occupations, effort must, of necessity, wait upon opportunity. Tides must be taken at the flood, and hay gathered while the sun shines.

In demanding the right to exercise their functions, the trade unions must of necessity display their capacity for apprehending the extent to which their demands are possible of realisation, and the point at which reaction becomes inevitable.

Inside the unions there are indeed many who understand the danger of a high minimum wage, and a low universal maximum period for work. They fear that the advocacy of extremes may penalise almost equally, though differently, the skilled and the slow. For the former there may be inadequate remuneration, and for the latter inadequate employment. If it is necessary to fit the punishment to the crime, it is necessary also to fit the reward to the effort.

The conditions under which employment shall be provided or undertaken divide themselves into those which belong wholly to the union and those which may, without serious disadvantage, be undertaken by the State. In the former are included methods

of production, and in the latter questions of industrial hygiene and common law. The unions might, with some show of justification, claim the right to intervene in both, but, whereas their claim in respect of workshop hygiene and common law might be questioned, in method it is indisputable. The conditions under which work shall be performed; what shall be the day or the piece rates; how the men shall be apportioned to machines, or in gangs; the size of the task where the task method is employed; the times at which work shall begin and cease; all are questions which the trade union may fairly claim to discuss with the employer. But where sanitation, cleanliness and deliberate theft, such as time cribbing, or such theft as may arise from payments in kind, are concerned, the State can most easily secure that uniformity which makes for health amongst workpeople, and equality of opportunity as between employers.

After wages, hours and working conditions, there is no subject so interesting to workmen and to trade unions as compensations for accidents arising out of, or in connection with, employment. To the accident proper has now been added industrial disease, and no trade union considers itself up-to-date unless it provides special, and if needs be, legal assistance in cases of accident or industrial disease. These cases afford one of the few opportunities the trade union official has of going into court, on equal terms with the lawyer. As a rule, some official of the unions specialises on this subject, and where questions of fact only are considered, he is often a more successful advocate than the lawyer. Even where questions of law are involved, he is sometimes, owing to specialisation, able to do all that is necessary.

The value of the trade unions performing this particular function must have been obvious, or Parliament would not have conceded so much of legal procedure to them. It was generally known that workmen, left to themselves, often failed, either through fear or ignorance, to notify accidents within specified times or in the manner necessary to ensure payment of the compensation to which they were entitled. When it became not only possible, but customary, to claim through the union, fear became less common, while ignorance was assisted.

Early in their existence the trade unions realised that wages were affected, if not altogether regulated, by the laws of supply and demand. If the supply of labour was greater than the demand, the market value of labour depreciated. They were not able to control demand, but they saw some possibility of regulating supply. If, in bad times, the unions could hold back what was surplus to requirements, they might maintain wage rates and working conditions exacted during times that were favourable. They could only hope, however, to hold back this surplus of labour if they could offer it subsistence.

The wiser organisations, recognising this, added various forms of unemployment benefit to their objects, and in doing so, did more than restrain surplus labour,—they went far to disarm the hostility of women. These, poor things, carried and their sisters continue to carry, the major portion of unemployment's burdens. Upon their shoulders rests much of the responsiblity for the maintenance of the home. They knew from experience that hostility to the interests or the apparent interests of the employer, or to their unrestricted authority over their employees, brought punishments, which might include dismissal and boycott. Because they knew this, and preferred reduced standards of living to no standards, their influence was usually against their men's association with organisations formed for the definite purpose of waging war upon employers, whose ability to punish approached the absolute. The women were not satisfied with the conditions obtaining, but they were afraid. The provision of unemployment benefit reduced their fears and helped to bring them on to the side of the unions.

The assumption by the unions of the whole of the burden of unemployment relief was inevitable. They had in those days no possiblity of help from elsewhere. Their existence was resented; they were regarded, and described in law, as organisations in restraint of trade, when it would have been wiser and truer to have described them as organisations in restraint of unscrupulous traders. I have often felt that this error in description emphasised bitternesses, developed industrial unrest, and 'sequentially cost the country hundreds of millions in disputes that were preventable had better relationships existed.

The employers, in those days, gave little encouragement to social aspirations or cultural tendencies. Then, as now, many failed to see the wisdom, or the economy, of taking a hand and bearing a share in

unemployment costs. Instead of collectively helping in times of stress, they too often rejoiced when funds failed, because an empty trade union exchequer meant ineffective trade union opposition to what was regarded as the employer's right to control his own business. By this was frequently meant the right to depress at will, and even apart from the suggestion of commercial necessity, the wages and the working conditions of their employees.

In face of the fact that the Israelites crossed the Red Sea because of the unrest obtaining in Egypt, it would be absurd to charge the British employer with all the responsibility for its existence. But there is no escaping the conclusion that in the days of industrial transition he did little to obviate this unrest, or to encourage that mutual understanding between capital and labour, without which neither can be even reasonably successful.

The mental conception of industrial economics which led the unions themselves to undertake the provision of unemployment benefit continued to operate until the advent of what was known as the new unionism. Then, for many people, the outlook changed. The conception of numbers and the power of numbers grew, and faith in the political solution of economic problems was revived. To secure numbers, it was necessary to reduce contributions, and unemployment benefit, being after strike benefit the most expensive, and involving the greatest actuarial uncertainties, was jettisoned in order to meet the demand for cheapness. In some of these newer organisations the contributions were so low that continued existence would have been very difficult had it not been that an appreciable portion of the membership was of the "in and out" variety and seldom became entitled to all the benefits set forth in the rule books.

It is significant, and flattering to the older generations, that these unions with new policies, while eliminating the responsibility for providing funds for unemployment, consistently insisted upon their right to administer the benefit, even when the funds were provided by the State. It is less than two years since the Parliamentary Committee of the Trades Union Congress placed an embargo on trade union association with unemployment administration if Friendly Societies were allowed to participate. This embargo has not, even yet, so far as my knowledge goes, been officially and publicly withdrawn. The point of view was emphasised by the General Federation of Trade Unions, which sent delegates personally to press the claims of trade unionists upon the Ministry of Labour. Their action was not prompted by hostility to the Friendly Societies, but by fear for themselves. They realised the danger that would threaten trade unions if surplus labour received its subsistence through other media.

The Government accepted the contentions put forth on behalf of the trade unionists. Personally, I think the Government had no option. The unions had established at least a squatter's right. They had been first on the pitch, and during a hundred years had spent many millions of pounds on unemployment. Where employers had shown any desire to collaborate, they had also, actuated alike by considerations of mercy and self-interest, set up forms of machinery for returning their members to employment. The Act of 1920 gave them large powers and small financial responsibilities. The men of 1820, the pioneers of trade unionism, were faced with almost similar circumstances. Had they been given similar opportunities, they would, I believe, have made infinitely better use of them than did their present-day successors.

The failure to exploit successfully the 1920 Act arose from rampant competition between the unions, actuarial ignorance within the unions, and within the Government, and the belief, which was almost as common as it was baseless, that new standards of living could be achieved by enlarging the powers of bureaucracy or by changing forms of government.

Common consent has given Mr. Lloyd George the honour of first voicing the possibility of receiving ninepence for fourpence, but he was neither the first nor the last to convey the impression that he was putting such a possibility into practice. He had eloquent predecessors, and he has equally voluble successors. Anyone reading the leaflets issued by some of the trade unions during the controversies which immediately preceded and succeeded the passing of the Act of 1920 will find ninepence for fourpence transcended by a pound for sixpence. Whatever calculations these unions made must have been based upon limited experiences with small benefits, and during a period when memberships

were increasing much more rapidly than liabilities were maturing. Their calculations were undoubtedly affected by the errors of the Departmental actuaries, who assumed that the average weeks of unemployment would be two-and-a-half, and seeing these figures, unions possessing hundreds of thousands of members joyously proclaimed their willingness to pay a pound per week for a sixpenny contribution.

How the officials of these unions expected to pay fifty shillings, plus costs of administration, out of twenty-six shillings, not even the Delphic Oracle could say. They never attempted to say. They carried on for a few months until bankruptcy overtook them, and then they suspended benefit. Some of the circulars announcing these suspensions and renunciation of future effort are pitiful admissions of ineptitude. All the excuses put forward in extenuation are feeble. There are usually not more than two general ones. They had to make grandiloquent promises in order to outpromise the competing unions, and they regarded the Government's estimates as providing wide margins of safety.

While folly and incompetency existed, it is comforting to realise that it was not universal. Some of the unions, and amongst them some of the semi-skilled and unskilled ones, kept their heads, and in spite of the competitive threats formed their schemes so as to keep them solvent. Recently, from conversation with Mr. J. N. Bell, the Secretary of the National Amalgamated Union of Labour, I gathered that this Union had a scheme which had, so far, weathered the storm and that he was optimistic concerning its future.

Incidentally, I may say that the General Federation of Trade Unions prepared a scheme when trade unions seemed to anticipate opportunities of usefully administering the Act. It rejected the official estimates of two and a half weeks, and based its calculations on five. It was the opinion of the Committee that post-war circumstances would involve at least this amount of unemployment. When it became the obvious intention of unions and the Government to let things rip, the Committee refused to join in dangerous competition, and wisely put its scheme in the waste paper basket.

All this may be said only to weaken the claim of the unions to deal with unemployment insurance. It would, if all the failures were failures of normal times, and were wholly chargeable to the unions. But the period of this great experiment was not normal. Mentally and physically, there has been great national impoverishment. The war involved the best of the people in the highest percentage of mortality. The numbers of those whose idealism finds expression in the greatest devotion to duty, and the greatest willingness to sacrifice, have been grievously reduced. Admittedly, the trade unionists, together with other people, ran after economic heresies, but experience is driving them to renounce these, and I still feel justified in insisting upon their right to deal with unemployment.

It is open to anyone to recall my own contention that the right to administer unemployment involves the duty of trying to understand the causes. I agree, and for years I have, in writing and in speaking, pleaded for the non-partizan study of the subject. I am not the only one. Others before my time have pressed this point of understanding. More than a hundred years ago the House of Commons discussed the subject, and then there was the same haziness concerning causes, the same ill-considered rush for palliatives and the same incentive to pauperism.

As far as one may judge, the only difference was one of attributed cause and degree. They had to deal with sixteen millions ; we have to deal with forty-eight. They argued that it was due to the deficient harvest. Our socialists and communists argue that it is due to capitalism, and the Prime Minister has declared it was due to the war. Charles James Fox, while admitting that war was responsible for some of the trouble, exclaimed: "But, if there are other circumstances which have operated along with those arising out of the war—if the evil has proceeded from many and complicated causes—nothing can be more mischievous than to ascribe it solely to one cause, and to proceed as if that were the fact."

Error is not the prerogative of the trade unions. Others with wider experience and better opportunities have erred in exactly the same way, and it may safely be assumed that error, and the consequences of error, will continue until the men who are most desperately concerned have placed more definitely upon them the responsibility of studying and mitigating this life-destroying problem.

Many who regard the right to treat this function as next in importance to the functions relating to strikes, recognise the difficulty of securing by voluntary means the necessary contribution. The workman is not much better as an economist than is the Government. Perhaps the outstanding difference between them is that the former wants a lot for nothing, while the latter gives a lot for nothing. Some form of compulsion appears to be inevitable, and if compulsion is applied, it should be by those most directly concerned, that is, those who live by the industry. And by those who live by the industry is meant those who live by wages, and also those who live by profits.

In the scheme put forward recently by the General Federation of Trade Unions, it is suggested that each industry shall provide and administer its own unemployment fund; that the industry, rather than the union, shall be the unit, and that contributions shall consist of a percentage on wages.

Personally, I care little whether the workman or the employer is the one who actually pays the contribution. In any case, it will come out of the industry, but for the sake of simplicity and economy in connection with administration, it seems preferable that the employer should be the actual payer.

It will be objected that industry cannot bear this charge and that a residuum of unemployed would be left outside the industries' schemes. I should give the same answer to the first objection as I gave to the Manchester Chamber of Commerce, viz., that the industries were already bearing the cost, plus the cost of bureaucratic administration and that of moral deterioration.

For the workers who cannot be grouped in specific industries there is always the possibility of a common society. Such a society, by reason of the diversity of its risks, might more than hold its own. There remains, of course, the residuum which would include unemployable, as well as some other unfortunates.

Expressing entirely my own personal opinion and realising that what I say may be both misunderstood and perverted, I cannot see anybody better fitted to deal with these cases than the Boards of Guardians. The Guardians are like the dogs with the bad names, and their early-Victorian records do not suggest that they then overflowed with the milk of human kindness. But they are popularly elected bodies, and as such, are much more amenable to enlightened public opinion than is appointed bureaucracy.

In any case, I cannot see how a country impoverished as is Britain can afford the luxury of several government departments to deal with what is, after all, one problem: the problem of maintaining life when life is jeopardised by unemployment arising out of industrial stagnation, physical incapacity, or culpable idleness.

Such schemes will be fought by those who aim at perpetuating the antagonisms between capital and labour, but this form of co-operation would do more to perpetuate industrial peace and to stabilise industrial enterprise than any other conceivable effort. Such schemes offer the employers a chance of demonstrating their interest in those who work, and they offer the trade unionist and the willing worker a chance of separating themselves from those who only work under compulsion.

Perhaps one ought to apologise for devoting so much time to this particular function. But it is the function of the moment and unless something is done, and done quickly, neither trade unions nor national existence can continue.

The question will certainly be asked—ought trade unions to claim political, as well as economic and benevolent functions? I have in a sense anticipated this question by stating that, in my opinion, they are justified in using their votes and their influence in favour of any party that can help them, or against any party that is hostile to them. Where I join issue with many is against the demand that they should forfeit their autonomy and jeopardise their industrial interests and create dissension amongst their members by tying themselves, for all time, to any one political party, or to any one form of religious thought.

I never claim altruism for the trade union movement. Its business is to look after the wages, the hours, and the working conditions of its members. It has no real obligations to those who are not members. Their remedies, if remedies are needed, lie elsewhere. I have been asked whether a trade unionist ought not to use his political as well as his trade union arm, and my answer is an unequivocal yes. But he should, in developing the political arm

see that the trade union arm is neither tied up, nor broken, nor withered. He should also be careful to see that it is not used to cut out his own stomach.

The political propaganda which preceded and culminated in the Miners' dispute paralysed that great industry and nearly paralysed the State. The miners suffered for their attempt to achieve a political result by industrial action, and they are suffering to-day; but there are other industries who suffered more, and who will suffer longer. Strikes and threats of strikes to achieve political ends, by retarding normal recoveries, have done almost as much to accentuate misery as did the war.

It must always be so. The objectives and the responsibility of the trade unionist and the politician differ. The latter has no aftermath that need trouble him. He can, and he often does, cynically ignore that part of his propaganda which turns out to be unprofitable. The trade unionist is differently situated. He must face the facts of failure, and if he has any heart, it will be lacerated by the results of failure.

Having passed through many strike experiences, I would limit their number by eliminating the political one. I would also eliminate the political control of the unions' activities.

Perhaps the only time I should consider an industrial strike in furtherance of a political objective justifiable, would be if the need arose to strike against an attempt on the part of politicians to limit the right to strike.

My friend, Mr. Archie Crawford, Secretary of the South African Federation of Trade Unions—at one time deported from South Africa because of his trade union activities, has recently declared that the economic law is inexorable. He is right. However opprobriously we may speak of the operation of economic law, we cannot escape the fact that it is inexorable, and that it is folly to accentuate its burdens by the assumption of responsibilities that arise from following political objectives.

The trade unions cannot, with or without political alliances, resist the operation of economic law, but they can, by the perfection of their organisation, and the creation of necessary financial reserves, prevent, or at least, oppose attempts to add to the pressure of this law by expressions of human selfishness.

They can, and should, fight the employer who seeks to transfer all the losses arising from his incapacity or lack of foresight to the shoulders of his workpeople. They are justified in condemning and fighting the employer who seeks to perpetuate a ten per cent. dividend plus payments of income tax, plus liquidation of share liability, plus share inflation, at the expense of the permanent stability of the business and at the risk of creating unemployment amongst the people who have made such dividends and arrangements possible.

In conclusion, I desire to reiterate my earlier contention that trade unions are entitled to claim as their rightful functions all those problems which deal with employment and unemployment.

DISCUSSION

THE CHAIRMAN (Mr. John Murray, M.P.), in opening the discussion, said the meeting had had the advantage of listening to a brilliant paper, packed with knowledge and information, and the result of those qualities, wisdom and sense.

Before commenting on it, however, he desired to read an extract from a letter from Sir Alfred Yarrow, who was unable to be present:—

"In connection with what we may call 'Labour questions' I should like to point out a matter which appears to me not to have had sufficient importance attached to it.

"It has been generally received that wages should rise with the cost of living; under normal conditions that is quite correct, but I think it must be admitted that every section of the community should pay something towards the expenses of having been freed from the German peril.

"Some have lost their lives, some have lost their limbs, capitalists have lost money, and, if those who work for wages have their wages increased to correspond to the increased cost of living they will not have paid anything towards the expense of the war, which they certainly ought to have done. Therefore wages to rise in proportion to the cost of living without allowance being made for the workers' share in the cost of securing their safety at home is, on the face of it, unjust to those who have suffered."

Personally, he agreed with Mr. Appleton that trade unions should not attach themselves to any one political party, but should use all. Neither politics nor the trade unions had anything to gain from the close union of trade unions with any political party. The author also said that the standard of living could not be raised, maintained or prevented from falling by a bureaucracy, and that was profoundly true, although many millions of people in this

country did not believe it, but argued superficially, from their experience during the war, that with the right people in the Ministry of Labour and the House of Commons wages could be maintained—disregarding the inexorable economic laws to which the lecturer had referred.

He agreed with the lecturer that the provision of "useful" work in times of unemployment was only of value in so far as it served to keep the peace at home; it was only by the re-establishment of foreign trade that any real good could be done. He agreed also with what the author said about subsidies. People were always shouting "Give, give, give," and wanting grants, doles and contributions for all manner of purposes; but when, in order to find the money required, the Government imposed taxation, those same people were loud in their complaints. It was necessary to exercise common sense and give up the incessant clamour for Government help and grants, which could only be provided out of taxation.

The lecturer said he did not wish politicans to toy with the idea of limiting the right to strike Politicians had a greater sense of self-preservation than to wish to do so. The further remark in the paper, that the right to discuss a subject implied the duty of trying to understand it, was so straight and true as to be almost offensive. The state of most men and women towards economics was a state of either first thoughts or second thoughts. The first thoughts consisted of all those follies and fallacies which people, looking at the phenomena of work and money and exchange, imbibed at once and believed to be true. Then came the economist, whose aim it was to replace those first thoughts by second thoughts. The wage-earning population was dominated by its first thoughts, and had a very weak sense of the continuity of causes and effects. The lecturer talked of action and reaction, and throughout his paper implied that the world was a system, and as such could not be interfered with without some difference being produced and without the working of it being affected. The wage-earners as a class had not had sufficient education to appreciate that; they thought there could be a break between cause and effect, and that if one only did a thing once or did it furtively nothing would happen. The working classes had two great misconceptions. They believed that the rich were not really subject to inexorable laws and influences but were, as it were, shock absorbers. If seven workmen indulged in "Ca' Canny," so that an eighth man and a boy had to be employed, the eight of them saw a certain resentment in the office, and imagined that was the only result produced. They did not appreciate the fact that the people in the office had to take steps to meet the altered situation by raising the price of their commodity. That meant that customers bought less, and therefore the wholesaler ordered less from the manufacturer, who then dismissed the eighth man and the boy.

To take another point, there was a great sentimental outcry in favour of a tax-free breakfast table. The money had to be found in some way, however; a tax-free breakfast table merely meant that some other table had to be taxed; but millions of people could not be made to see that. In the case of income tax, the poor man said: "I am poor; don't tax me; go for the rich." He thought the rich man would grumble, but that would be all. But as a matter of fact, if the rich man was an employer, the result would be that he would employ less; if just a saver, who put money in the bank which was used for trade, he would save less, and so employment would be reduced all round. In short, the system of organised work within a nation and interchange among nations was a system which kicked back; if one interfered with it at one point, one could not be sure the result would not be felt at ten others. He did not know how that was to be brought home to the wage-earning class except by years and years of educational effort.

He did not altogether agree with the author's strictures against the Government in the matter of unemployment The Act of 1920 brought twelve million workers within the scope of compulsory unemployment insurance, which was a bold beginning, boldly made at a time when everyone knew a change for the worse was approaching. But for the miners' strike last year the increased benefits brought into force on March 3rd, 1921, might have been maintained. The conditions had since become more serious, so that he believed the Government would have to re-consider from its foundations, for the period of the present emergency, the conditions under which unemployment pay was granted. They would have to think not of the individual, but of the family or family group Unemployment in normal times was a burden the State could bear, but when one had to deal with people who had been unemployed not for two and a half or five weeks, but for two and a half years, no normal method would meet the case. The burden was too great at the present time for the industries themselves to be asked to undertake it, although that might be the ideal method.

It was possible that, instead of a centralised bureaucracy at the Ministry of Labour, some attempt might be made on the lines of what had been done in regard to local educational authorities in the big towns. Local industrial authorities might be established on which the employers and trade unions might be represented, so that in every industrial area there would be a competent statutory body capable of dealing with all the problems that arose. In his opinion, the great problem before the country to-day was that of decentralisation, by which he did not mean sending officials from the bureaucracy

in London to the provinces, but cutting down the bureaucracy in London by passing on its functions to autonomous local bodies in the provinces. The policy of "give, give, give" and "take, take, take," meant that all the money of the country circulated through Parliament, through Westminster, which meant that much of it was wasted there and on the way up and back, maintaining hordes of bureaucrats That money ought to be spent locally by local bodies, and, although that might mean a complete reform of our local government system, there was no reason why that should not be undertaken. The nation was, although tired, in a constructive mood, and was crying out for decentralisation, although nothing, so far, had been done. Autonomous local bodies with real powers and control of money were wanted; the Chancellor of the Exchequer and the Treasury should be steadily deprived of their money functions, and those vested in local bodies; otherwise the temptation to corruption in the central government and the evils which arose from ignorance and inefficiency would only grow.

MR. CECIL WALTON (of Messrs. Lever Bros) said he had travelled up that day from a little village in Cheshire called Port Sunlight His firm had many battalions of people working for them there, while in their overseas plantations and concessions in various parts of the world they employed countless thousands It was his duty—or, as he preferred to say, his pleasure —to control that great mass of labour, and he was therefore in constant touch with the grave problems which that involved, and in constant touch with the trade unions and all their activities He had a very great respect for the trade unions

In 1913, a man in Dresden said to him: "We Germans realise that you English people are complicated thinkers, and we are doing our level best to encourage you in complicated thinking." He treated it as a joke at the time, but it had been borne home to him recently that the remark was true; the English were a nation of complicated thinkers There was very little clear thinking in connection with industry in this country at the present time. Taking the question of wages as an example, the country was threatened with a great industrial calamity by a suggestion that the wages of engineers should be reduced to a certain level. Without entering into the merits or demerits of that suggestion, he might say the suggested reduction in the wages of those skilled men, who had served long terms of apprenticeship, would place them on a level far below that occupied by the unskilled labourer to-day. Only that morning he had suggested at a Conference, a reduction in the wages of a large body of unskilled men—a reduction which would, however, leave them far above the standard offered to the engineers—and was told that it was a wicked and pernicious suggestion. During the last few days one of the Wage Boards had ruled that the unskilled labourers attached to electricians on railways should receive 13/6 a day, and the linesmen on the railways a minimum rate of £1 2s. 6d It was the complicated system of thinking on such matters, and the anomalies it produced throughout the country, which were causing all the trouble at the present time Wages and hours of labour had nothing to do with the question which was really tied up with production. During the war, this country multiplied its effort by something like fifteen times, but as soon as the war was over it reverted to pre-war practice in that respect If the country would only double its productive effort now--which could easily be done—the question of wages and hours would not come into the picture at all. During the war a great army of unskilled men and women were taken into industry and trained, serving, as it were, an apprenticeship. By the time the war was over they were, if not fully skilled, at any rate semi-skilled, and they objected to being disbanded As a result the unions were split into two camps—craft unionism and trade unionism The great question to be decided at the present time was whether industries should be governed industrially or governed by the craft unions To imagine that because trade unionism was at the present moment under a cloud, it would never come back in its strength was a great mistake; it would come back stronger than ever The wise employer and the wise union would take advantage of the present period of comparative peace to put their houses in order, so that if all that was bad in craft unionism came back it would be found to be unnecessary If the trade unions came back not as antagonists but as assets, there was nothing on earth that could stop them from coming into co-partnership in industry

The question of measures for the prevention of unemployment was a great field which might, with advantage, be explored Personally, he had given a great deal of consideration to that matter during the last twenty years If the unions were to be asked to give up much for which they had—and rightly—fought, and allow full and unfettered production, they had a right to ask for something in exchange The wise employer would say: "If you will give us this, we will guarantee you against unemployment " That could be done, in his view, quite easily. It could not be done out of profits, which were required for something else, but might be done in the following way Suppose the output of a certain business was x, and the establishment charges were a certain figure. Those establishment charges would vary a little, but only a very little, with any increase of x. The increased effort which must reduce

those establishment charges would create a fund, part of which could be set aside as a guarantee against unemployment.

So far as his own firm was concerned, under the lead of his great chief—who, incidentally, he considered was the greatest industrial leader the world had ever seen—they were going to devote their time to caring for the human element in their industry in the same way in which they cared for the mechanical element It was his duty to look after those people, and he found a very great joy in doing it When one saw them all gathered together in a large hall, where one could talk to them not as official director of a company but as a man speaking to men, one felt that a great crowd like that was the most wonderful instrument in the world, and if one only played on it carefully one could extract the most wonderful music.

MR. R. McLAUGHLAN (London District Organiser, Electrical Trades' Union), thought superficial, rather than complicated, thinking was one of the difficulties with which this country was faced at the present time. That man's activities, whether political, religious, or judicial, are determined by the method whereby he obtains his livelihood is not yet generally recognized The author suggested that the trade union movement should cut itself clear of any political party, but a concrete manifestation of the fact that political activity was a reflection of economic interest was provided by the representation of the Federation of British Industries in the House of Commons to-day. If it was logical and sound for one class to have that representation, it was equally so for the other class. The power of the trade unions to get to grips with the questions which faced them was impaired by the fact that their members had not had the facilities for education which were necessary to give them the power of analysing the problems with which they had to deal. Professor Huxley once said it was a crime to give a man a vote unless one gave him the power of understanding how to use it, and with that he agreed. It was illogical, however, to expect the employers to have any desire to place in the hands of the working classes a weapon which would enable them to emancipate themselves The author referred to the "fanatics and scoundrels" who were responsible for such propositions as that put before the trade unions in the mines dispute. If, however, he took the trouble to analyse that proposition he would find that it was the result of outside conditions over which no one connected with it had any control. The Chairman, in dealing with the "Ca-canny" movement, and the resultant increase of price to the consumer, had not mentioned one factor which controlled prices, namely, cost of production. The real evil, in his view, arose from the fact that production was carried out socially, ownership being individual, from which arose an antagonism, *i.e.*, "The Class Struggle." Under the present condition of society, there was no possibility of any mutual understanding between capital and labour. However much employers might desire to bring about this mutual understanding, they were face to face with an economic factor over which they had no control. Both labour and capital were part of a great system which controlled them rather than being controlled by them. That would continue to be the case until production for use was substituted for production for profit. When that came about there would be no need for trade unions or employers' associations

MR JOHN BAKER (Iron and Steel Trades' Confederation) complimented the author on his paper, which he thought was a valuable contribution to the subject with which it dealt. The author, however, knew him too well to expect him to agree with everything contained in the paper. He accepted the dictum that one had no right to meddle with a problem unless one tried to understand it. He believed the author had always accepted that principle, and it was unfair to suggest that "if he would take the trouble" to do something he would arrive at a different conclusion. It was not so much from complicated thinking or superficial thinking that the country was suffering, but from lack of thinking; people were not prepared to collect all the facts before arriving at a conclusion. The part played by the miners' strike in producing the present depression was exaggerated, and the fact that a similar state of affairs was prevalent in America, China, Australia—indeed, throughout the world—was overlooked It had been stated that this country increased its productivity fifteen times during the war, but it must not be forgotten that, during that period of increased productivity, there was not a single moment when the workers did not have to fight to get an extra shilling added to their wages. Commissions of Enquiry, the members of which were presumably independent, had reported that it was the bread-and-butter question, the difficulty of existing on the wages paid, which produced the unrest then prevalent.

At a time like the present, when it was impossible to sell all that was produced, it was folly to ask the workers to produce more. In the trade to which he belonged, the relations between employers and men had been of a fairly friendly nature, and at one time they had discussed the possibility of making the trade responsible for its unemployed; but, before anything could be done, the slump came. At the time the matter was under consideration it was thought that 6d. a ton added to the price of steel would produce sufficient to permit of a reasonable allowance being given—not fifteen or twenty shillings—to all men unemployed; but, of course, that could not be done at the present time. Although, under present

conditions, the author's suggestion in that respect could not be put into effect, he regarded it as a valuable one. The employer who boasted that he was an employer should accept the responsibility of finding work for those who desired it, just as he expected a workman to do any work offered to him The employer who asked a member of his staff to work overtime when an ex-member of his staff was unemployed should be ashamed of himself; the employer who claimed the right to manage his own works in his own way was claiming the right to control the lives of his workers, and such a claim was insupportable The iron and steel industry should be run for the benefit of workers and employers alike It was not to the advantage of the workers that the iron and steel masters should be ruined; the workers should take an interest in the management of the business, and try to extend it in all its ramifications The workers must not have a policy which would ruin the works, and the masters must not pursue a policy which would ruin the men

MR. J. J HALL (Secretary, Silk Hatters' Trade Union) said that, besides being a worker—he had come from the bench that day—he was the Secretary of the oldest trade union in the world, a union whose charter went back to 1604 and which received Royal permission to associate in 1576 Trade unionism, therefore, was no new thing. History showed that trade unions should not rely on political effort alone: the greatest factor they could rely on was their own resources, financial and physical If all the unions would work together, increase their subscriptions and place themselves on a reasonably sound financial basis, capitalists would be helpless As soon as trade unions were made into political organisations corruption crept in To substitute the State for private individuals as an employer would be a great mistake: it would destroy the initiative and individuality which had raised this country to the position it occupied to-day. During the war the State subsidised the workers at home at the expense of those who were fighting for their country abroad, and even had to bring workpeople over on holidays to France, to see the conditions which prevailed at the front, in order to get them to work. The employers themselves were largely responsible for the "Ca'-canny" policy the Chairman had mentioned. When machinery was first introduced, the employers found their men were making such good money on piece rates that they introduced the day rate. If the workman was playing "Ca' canny" it was the employer who taught him to do it.

MR. APPLETON, in reply, said he had been much interested in what the Chairman had said about decentralisation. He thought there was a good deal in it, but would like time to consider itMr. McLaughlan seemed to think that the political activities of the Federation of British Industries disposed of the contention that it was a mistake for trade unionism to ally itself permanently with any one political party. That was not the case. The Federation was doing exactly what he would like the trade unions to do—using any party which happened to be in power and taking advantage of any circumstances which arose. The question of educational facilities was constantly being raised. In his opinion, there was no country in the world where the educational facilities were so good as in Great Britain: it was not lack of educational facilities but lack of educational inclinations which was the trouble at the present time. Personally, he was at school only on odd days and odd weeks prior to the coming into force of the Education Act The educational facilities in those days were not very good, but he had taken advantage of them and would perhaps feel a little hurt if described as a wholly uneducated man He was satisfied there was no justification for the whine about lack of educational facilities which was constantly being raised. He had served for nine years on an educational authority which literally went out into the highways and byways to get people to come in, but one could not keep them; although every inducement was offered they would not complete their courses. Some disappointment was felt on that account, and fear as to what would happen to a country where people refused to take advantage of the facilities offered. During the last twenty years he had not come across any hostility to education on the part of employers; they were much too astute to oppose the mental training of their workpeople; the man with a trained mind was a more valuable asset than the man with no mind at all or with an untrained mind. He opposed the general strike because a general strike involved all the people, and 95 per cent. of all the people were working people, who would be badly hit by such a strike, or even the threat of it. In 1919 the exchange with America had begun to go in favour of this country, when a sudden railway strike took place. That immediately arrested the change, and sent prices flying up again. One consequence of that was that Lancashire had to pay about two hundred millions a year more for her raw material than she would have done had the exchange been normal. The price of commodities was largely fixed by the buyer. The employer might try to get the highest possible profit and the workman the highest possible wages, but in a country such as this, where three parts of the people were dependent on overseas trade, prices were largely fixed by the overseas buyer. If our prices or quality were not satisfactory to him, or the goods could not be delivered when he wanted them, he would cease to buy, and unemployment resulted. He believed that the interests of employers and workpeople were, to a large extent, identical. While labour might be a commodity, it was also

capital, and, because it was capital, there was a certain affinity between it and its employers. He had no desire to see any class concentrate itself on purely class interests, because that meant the selfish subjugation of the other class, and, even if the other class was in a minority, that was unfair. It was all very well to say that it would be better to produce for use instead of for profit, but he could not undeistand why some of the mighty Empires of the past, some of those great brains to which we still paid homage, had not discovered the method of doi g this a thousand years ago and put it into piactice. In regard to unemployment, the fact was sometimes overlooked that in France there were less than 10,000 persons unemployed, and in Germany he thought, only about 36,000. When one remembered the size of the population of those two countries, it made one wonder what was wrong in our industrial arrangements It was the country's business to find out what was wrong. He would like to remind his audience that a hundred years ago the House of Commons was discussing the question quite as intelligently as it was being discussed to-day. Incidentally, if the State became the employer there would be more need for trade unions than ever before. Unless the cause of our present troubles was ascertained and removed, we would go out of existence just as surely as did Greece and the other great Empires of the past

THE CHAIRMAN, in proposing a very hearty vote of thanks to the author for his paper, said the method he had adopted in dealing with his subject should serve as a model to other investigators. No man in all England had a better knowledge of everything connected with the trade union world and the life and opinions of the wage-earners than the author, and to the study of those things he brought real thought and largeness of mind and patience Unlike many who concerned themselves in economic and industrial questions, who seemed to have been born in the first year of the war, he had a wide knowledge of history, and had shown how to take a long and wide—and therefore a wise—view of the problems which confronted this country at the present time

The vote of thanks was carried unanimously, and the meeting then terminated.

MR. E. C. DE SEGUNDO writes :—

Mr. Appleton well reminds us that "the right to discuss a subject involves the duty of trying to understand it." There are few matters upon which the average man is less well informed and less capable of forming a balanced judgment than upon the proper relations between "Capital" and "Labour." This is largely due to the fact that information upon the que tions at issue is only obtainable by the general public from *ex parte* statements on either side. Mr. Appleton's book, "What we want and where we are," constitutes a valuable contribution to the literature on the subject. Controversy between "Capital" and "Labour" will never convince the public of anything except of the existence, or rather the persistence, of antagonism between the two, and will assuredly not help to "encourage that mutual understanding between Capital and Labour, without which"—and here Mr. Appleton strikes the keynote of the whole matter—"neither can be even reasonably successful."

How is this mutual understanding to be brought about? Mr Appleton answers this question in his book to which I have already referred. He says, "The treatment of unrest must be educative as well as palliative. . Any system of educa.ion which sets the material above the moral is self-condemned." He criticises our present system of education—and I think justly—in the following words: "Unfortunately, the profoundly important work of training the young has been left too much in the hands of the bureaucrat and the professional We have, in consequence, a people possessing a superficial smattering, but little love of knowledge for its own sake; a people who know little about themselves or about the facts which govern life"

The necessity for close and intelligent co-operation between Capital and Labour and the joint co-ordination of their respective resources has become very vital in view of the fact that only by the re-establishment of trade and industry, and particularly of our foreign trade, can we hope to persist as a nation

In this connection, the problem of unemployment (of capital as well as labour) stands prominently in the foreground. All that Mr Appleton says is very true Unemployment of labour arises from a multitude of causes and can never be wholly eliminated under any conceivable form of social economy. But the present extent of such unemployment can certainly be mitigated, and to this end it would be well if trade unions would consider it one of their proper functions to act upon Mr Appleton's advice and "tell the people the real truth about production and wages." This will, no doubt, involve some very distasteful lessons for workers, be they workers with their hands or with their heads. It will mean demonstrating, and acting upon (I don't know which will be the more difficult), the common-sense axiom which lies at the root of all sound economics, that *you cannot get a quart out of a pint pot.* Any section of the community which is in a position to render indispensable services can, by combination and organization, extort remuneration for service on a scale exceeding the economic limit for a time. In the long run, however, goods and services fetch what they are worth and no more. You can only *apparently* get a quart out of A's pint

pot by surreptitiously adding the contents of B's pint pot. The price of a commodity or the remuneration for service can only be kept above the economical level at somebody else's expense. As is evident enough to-day both in this country and in the United States, the continued raising of service-remuneration and lowering of service-value rendered, has brought in its train the Nemesis of inexorable economic fact—the unemployment of labour and of capital.

Both capital and labour overlook the truism that for every seller there must be a buyer. If buyers cannot themselves earn sufficient to pay the price for commodities determined by the rates of remuneration capital and labour fix for themselves, they go without, or reduce their purchases to a minimum, and it is obvious that *both* capital and labour sooner or later find themselves out of their jobs The United States possesses about forty per cent. of all the gold in the world and immense credit; but she has some 5,000,000 unemployed. Great Britain has little gold but some £2,000,000,000 of credit entries in the books of the Joint Stock and other Banks. She has nearly 2,000,000 unemployed. In the meantime, would-be buyers the world over, are screaming for the products of capital and labour—at a price within their reach.

In a paper I read in this room in February, 1921, I pointed out that without the vitalizing element of directive ability, capital and labour are inert, though indispensable, factors in wealth-progress. Mr Appleton supports this view in his book He says: "The enterprise of the thinker and fighter made possible the extraordinary increase in population (in England and Wales) which took place between 1801 and 1901." Lenin has at length admitted (*vide* the *Socialist Review* for January of this year) that his economic policy in Russia is a failure; that "the re-establishment of capitalism is radically bound up with our new economic policy" and that "the entire national economy must be based upon self-interest."

There is, however, one view-point which is often overlooked. The possessors of directive ability stand in a category by themselves. The exercise of ability is called into being solely by the stimulus of suitable inducement. Coercive measures operate only to dry up the well-springs of such inspiration. Now, I do not wish to be misunderstood in quoting Mr. Frederic Harrison who pointed out that "there is no case on record of a body of workmen creating a new market, or founding a new enterprise." This is no reflection upon the labourer, in the familiar sense of the term. It is not the job of the employed to undertake the speculative forms of activity and the risks inevitably involved in the establishment of new enterprises. But all ages, including our own, are full of instances of men in all ranks of life who have risen from humble beginnings to positions of power and influence. Mr. J. H. Thomas is reported to have said in the House of Commons on February 24th last that "He believed no country was more democratic than our own, and that the Constitution that enabled him to leave the foot-plate and take his place in Parliament was one that gave democracy all that it required."

In a recent lecture I ventured to draw attention to the loose thinking which is resposible for much of the misapprehension and misconception lying at the root of the bitter feeling between "Capital" and "Labour." I suggested the following definitions:—"*Capital* properly denotes anything, or combination of things, non-material as well as material, capable of being turned to useful account in the attainment of a desired end by means of directed human activities, and *labour* properly includes all such directed human activities, mental as well as physical, as are involved in the attainment of such end."

I venture to think that these definitions are true and are calculated to dispel the widely prevalent and deeply rooted illusion that capital and labour subsist in water-tight compartments, so to speak, and that their interests are inherently antagonistic

The ideals outlined in Mr. Appleton's paper and further elaborated in his book indicate that the most commendable motives underlie Trade Unionism, and Mr. Appleton, in common with many other leaders, deprecates the principle of attempting to solve economic problems by political action. We have seen, however, that the highest motives and the best intentions may be nullified where it is possible for extreme views to gain an ascendancy over mature judgment, and everyone would be glad to hear from Mr. Appleton that among the proper functions of the New Trade Unionism there will be included the form of education which he advocates so strongly, namely, the development in the members, and particularly the younger members, of that sturdy, healthy, moral sense which is the characteristic of the British Nation, coupled with the inculcation of a knowledge of *realities* as distinguished from academic theories; to the end that a recurrence of any concerted action so foreign to true Trade Union principles as that which caused incalculable loss and damage to trade and industry in the spring of last year, will become impossible.

I wish we had more Appletons in "Capital" as well as in "Labour." Those who know Mr. Appleton's work and his writings will agree with me that his attitude towards industrial questions is ever one of fearless and uncompromising honesty of purpose, and if the formulation of the proper functions of trade unions and the power to carry them into effect were vested in men like him the community would have no reason to fear the extension of the influence of Trade Unionism.

NOTES ON BOOKS.

THE PERIODS IN INTERIOR DECORATION. By Herbert Jeans. London: The Trade Papers Publishing Co., Ltd.

This handbook forms one of "The Decorator" series of Practical Books, which is edited by Mr. Arthur Seymour Jennings. The series has already established a reputation for itself as providing sound and well written text books for the various trades for which they are intended. Mr. Jeans's volume is designed for decorators, and gives a concise but adequate review of the principal styles of English decoration from Tudor times to the day of Morris. It is to be feared that the need for such a handbook is only too great. The average decorator has but the foggiest notion of "periods," nor does he seem to take any interest in the magnificent traditions of his callings. We should like to place Mr. Jeans's text book in the hands of every decorator, and when he has studied it, make him spend some weeks in the Victoria and Albert Museum, which, as Mr. Jeans's reminds us, has well been called the "Decorator's Paradise."

The book concludes with an interesting chapter on the progress of paperhangings in England, by Mr. Metford Warner.

DISTILLATION PRINCIPLES AND PROCESSES. By Sidney Young; with the collaboration of Lieut.-Col. Briggs, T. H. Butler, Thos Durrans, the Hon. F. R. Henley, James Kewley, and Joseph Reilly. London: Macmillan and Co. 1922. 40*s*. net.

The special value of this important addition to chemical literature rests in the admirable interassociation of practice and theory, numerous distillation devices being figured and elucidated by the light of modern knowledge, while the kinetic principles which bear on the possibility of effecting fine separations by fractional distillation are well explained in words, in mathematical study, and also are embodied in tabular form for convenient use.

Chapter X is typical of that feature which we refer to above as "admirable interassociation." The chapter opens with a drawing and description of a fractionating still head figured by Ustadius in his *Liber de Secretis Naturæ*, printed in 1553; then follows a note on the inefficiency of the plain still-head, another on Brown's formula, and a longer study of the theoretically perfect still head—which, like Carnot's Heat Engine, cannot exist as a concrete embodiment. Dr. Young next touches on the characteristics of a good still head, the comparison of still heads, mixtures, influence of rate, use of pendulum to secure even rate of dropping, explanation of tables, influence of length and width, and observations on the many existing forms. References to sources, authorities and papers containing collateral or supplementary details are given in foot-notes or otherwise.

The above is typical of the whole range of over 500 pages with 210 illustrations; about half of the book, being devoted to the laboratory aspect, and half to special industrial applications.

THE OIL ENCYCLOPEDIA. By Marcel Mitzakis. London. Chapman and Hall, Ltd 1922. 21*s*. net.

This is a practically useful reference book for those having to do with mineral oils or the like; and as it is in the dictionary form, with such cross references as are necessary, no formal index is required. The pages (large octavo), are a little over five hundred, and as an average we take it there are five or six articles to a page, but important subjects have adequate space, oil engines being treated of in four pages, and oil fuel in a trifle over four. A concise and lucid style, together with the fact that many references are given to the larger text books or specialised treatises, makes the work before us a convenient desk companion for the busy man.

It is, in short, a ready reference volume, without undue technicalities which should be at hand in every business establishment connected with the petroleum industry.

RESEARCH IN INDUSTRY THE BASIS OF ECONOMIC PROGRESS. By A. P. M. Fleming and J. G. Pearce. London. Sir Isaac Pitman & Sons, Ltd 1922. 10*s*. net.

There is a tendency, in the book before us, to make confident assertion in highly controversial matters. Thus (p. 1), we find a statement "Sociologists are agreed that . . ," the issue being our author's contention that ethical or moral progress is sequent to and consequent upon, material progress (pp. 1 and 2). These issues, and the question as to the moralising or demoralising influence of science (the habit of knowing) and of art (the habit of making) have, as far as we read history, been the most discussed of all the fundamentals of economics, and the issue on which there has been the most even division of opinion. The difficulties of associating that first element of morality, unsoiled verity, with certain details incidental to manufacturing and salesmanship, are obvious; putting aside ancient studies and the confident view of Ovid when referring to the golden age and his modified view with respect to liberal art (poesis, or the habit of making, in the higher sense, i e., without constructive material, and, broadly, including literary invention, verification, music and design). This is considered by Bacon (p. 66 of Bohn's English Version of Bacon's Chief Works); but turning wholly on the word "*fideliter*," the conclusion being otherwise reversed. Herbert Spencer was, perhaps, the first to apply quantitative analysis to data bearing on this matter (see his study of Sociology, eighteenth edition, London, 1879, pp. 439-440). From the general standpoint reference may be

made to Lecky's History of Morals, especially Vol. II., Chap. V.; also to the Encyclopedia of Social Reform by Bliss, New York and London, 1897, pp 895 and 896; The British Supplement to Bliss (1908), containing notable articles, especially under the headings Adulteration and Illicit Commissions.

That the spontaneous research work of the zealot who publishes unreservedly, has acted favourably on industry as a whole, appears to be beyond question; but such associated research as that which appears to have been carried out at the expense of the affiliated aniline-colour firms in Germany, seems to have had sinister results which the world is now experiencing—despite large pre-war profits to the interested firms.

Whether difficulties can be overcome by any such highly complex ordering of matters as that suggested in the book before us, appears to be problematical, as, apart from all questions of honest aims in the specialised research or uncandid items in publication, the incidence of the laws of increasing or diminishing returns (changes of ratio between effort and result), cannot easily be predicted. (See Walker's "First Lessons in Political Economy," Macmillan, 1890, pp. 25-33.)

The work before us may be studied with advantage by matured students of economics, who, it may be assumed, have taken to heart Bacon's cautions as to hesitancy in accepting the first offer of things.

THE COTTON TRADE AND INDIA.

The following views on the future of the Lancashire Cotton Trade by SIR CHARLES MACARA appeared in a recent issue of the *Manchester Guardian*:—

"I am sorry to see some of the operatives taking so gloomy a view because it seems to be based on a misconception of facts. Take the present position of the Indian cotton spinner and manufacturer In India there are now about 7,000,000 spindles to meet the requirements of a population of more than 300 millions It takes about 12 millions of our 60 million spindles to meet the needs of our people at home. And it has taken India well on towards a century to gets its 7,000,000 spindles. We have to remember also that the Indian spinner is greatly handicapped in his initial outlay. Where before the war it cost us at the rate of two guineas a spindle to put up our mills, it cost the millowner of Bombay four guineas, and the proportion is about the same to-day.* No doubt a great deal of the machinery now going out to India from this country was ordered before the war, but it will have to be paid for at the enhanced prices.

"It has been complained that Lancashire spinners and manufacturers have to contend also against longer hours and lower wages in the Indian mills That is true, but things are not as bad as they appear. England has led the world in reducing hours of labour. Here and in America hours in the cotton industry have been reduced from 55½ to 48 a week, but the Continent is following the example; India has just reduced its hours from 72 to 60, and night-work is to be abolished in Japan. And the process will continue until there will be uniform hours of work throughout the world. The reduction of 12 hours in the Indian mills will go a long way towards counterbalancing the difference between the import and Excise duties Then, although the individual worker in Indian mills gets much less than the Lancashire worker, he is nothing like as efficient One Lancashire operative is probably equal to three Indian, so that really the wages bill is not so small in comparison as many people imagine. A prominent Japanese told me that in his country they have to provide houses, music-halls, and theatres and do a variety of other things in order to attract people into the mills. Another item which is by no means negligible in the running of cotton mills in the east is the damage done to machinery by shocks of earthquake.

"Altogether then, prospects for the Lancashire cotton industry are not as bad as some people would have us believe It will be a very long time before India will be able to do without English cotton goods There are many millions of people there who have used very little clothing at all as yet And look at the possibilities in China, with its population of 500 millions and only about 2 millions of spindles"

* The cost of erecting a Ring Spindle Mill in England to-day is about £7 per spindle. In India the cost would be nearer £14 per spindle.

GENERAL NOTES.

PURCHASING POWER OF THE NATIVE POPULATION OF INDIA.—The United States Trade Commissioner in India reports that, as a result of an investigation made by the director of agriculture in Gujerat, a region in the Bombay Presidency supporting a population of 9,000,000, the native family of three adults and two children of the class owning small holdings of land spends annually 228 rupees The expenditure of the field labourer is, of course, less. An investigation in the region of the Deccan revealed that only 35 per cent of the families were entirely self-supporting. The chief demand for imported goods, except for cotton clothing, comes from landed proprietors, money lenders, merchants, and city dwellers, though the purchasing power of this class has not been estimated. The growing industrialization of India will, however, undoubtedly eventually effect changes in the economic condition of the native population.

BRAZILIAN CENTENARY EXHIBITION.—An excellent opportunity for British manufacturers and merchants to extend and open up new business in South America is offered by the Brazilian Centenary Exhibition to be held at Rio de Janeiro from September 7th to December 31st next, in celebration of the centenary of Brazilian independence. The British section is being organised by the Department of Overseas Trade. Brazil, in common with the other states of South America, all of which will have buyers at the exhibition, possesses immense possibilities for the future, little as yet having been done to develop its enormous resources. Britain's chief competitors there are the United States of America, who have voted one million dollars for official participation, and France and Belgium who have also voted large sums for the same purpose. Practically every country in the world will be represented. British firms will therefore do well to avail themselves of the facilities created by the Government's acceptance and vote of money for participation in response to the invitation of the Brazilian Government. Full particulars can be obtained on application to the Department of Overseas Trade at 35, Old Queen Street, Westminster, S.W. 1.

JAPANESE PRODUCTION OF CULTURE PEARLS.—According to a report by the United States Acting Commercial Attaché at Tokio, culture pearls are now being produced in Japan on a small scale by several companies, while one company is producing a variety which is very similar to the natural article. Some of these culture pearls are round and entirely coated, though most of them are flat on the back, where they are attached to the mother-of-pearl shell. It is stated that pearls are secured from about 80 per cent. of the oysters treated, and that they sell for approximately 30 per cent. less than the natural variety. While the production of culture pearls in Japan is evidently on a successful commercial basis, it is not probable, adds the Attaché, that this production, which involves a slow and costly process, will be large enough to affect the price of the natural product.

QUININE CULTIVATION IN THE PHILIPPINE ISLANDS.—According to the Director of the Philippine Bureau of Science, large available areas in Luzon and Mindanao Islands are highly adapted for quinine cultivation. At present there is one small quinine plantation in Baguio, which is under the supervision of the Bureau of Forestry, and the results obtained from its operation indicate the success of the industry. Climatic and general conditions in the Philippines are very similar to those of India, where there are quinine plantations contributing about 10 per cent. of the world's output, and to those of Java, which supplies about 90 per cent. of the world's output.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

APRIL 26.—JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the chair.

MAY 10.—MAJOR PERCY A. MACMAHON, R.A., LL.D., ScD., F.R.S., "The Design of Repeating Patterns for Decorative Work." SIR CHARLES CARRICK ALLOM in the chair.

MAY 17.—OSWALD M. SHEPHARD, "Recent Developments in Rubber Manufacture, with special reference to Rubber Machinery and the Manufacture of Tyres."

MAY 24.—GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

MAY 31 (at 4.30 p.m.)—LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:

APRIL 28. F. G. ROYAL-DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the chair.

MAY 26. SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced:—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION

FRIDAY, JUNE 9, at 4.30 p.m.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

JOINT MEETING.)

Friday afternoon, at 4.30 o'clock:—

MAY 5—PROFESSOR WILLIAM HENRY ECCLES, D.Sc. (London), F.R.S., Vice-Chairman of the Wireless Telegraphy Commission, "Imperial Wireless Communication."

Journal of the Royal Society of Arts.

No. 3,622 VOL. LXX.

FRIDAY, APRIL 21, 1922. 18 MAY 1922

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, APRIL 26th, at 8 p.m. (Ordinary Meeting). JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the Chair.

FRIDAY, APRIL 28th, at 4.30 p.m. (Indian Section). F. G. ROYAL-DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the Chair.

Further particulars of the Society's Meetings will be found at the end of this number.

PROCEEDINGS OF THE SOCIETY.

SIXTEENTH ORDINARY MEETING

WEDNESDAY, MARCH 15TH, 1922.

SIR ROBERT MOLESWORTH KINDERSLEY, G.B.E., in the chair.

The paper read was :—

CERTAIN ASPECTS OF THE PROBLEM OF EXCHANGE STABILIZATION.

By OSWALD T. FALK, C.B.E.

I shall discuss in this paper the problem of the stabilization of the gold or dollar value of sterling. If this subject is narrower then the title of the paper suggests, I must plead forgiveness on the ground that I had to choose the title before the paper was written.

In January, 1918, the Cunliffe Committee was appointed to "consider the various problems which will arise in connection with currency and the foreign exchanges during the period of reconstruction and report upon the steps required to bring about the restoration of normal conditions in due course." The two reports of the Committee were published in the autumn of 1918 and at the end of 1919. Very little thought was given to the difficulties of the reconstruction period ; it was assumed that the pre-war financial system was the goal to be aimed at, and attention was directed almost exclusively to a rather doctrinaire and rigid scheme for the attainment of this goal. Worst of all, the Committee made the mistake of discussing the problem from the point of view of finance rather than from the much more important point of view of industry, trade and the general welfare of the community. Our financial policy since the Armistice has not been a success, and for its failures the Cunliffe Committee are partly responsible.

But the sins of the Committee were mainly sins of omission, and it has not been any real or assumed obligation to obey the precepts of the reports which has caused the Treasury and the Bank of England to make their chief mistake of the last three years. During this period we have suffered from a wild boom, a disastrous slump and prolonged depression. A boom, a slump and depression we should have suffered in any case, but all three might have been less acute if those in control of financial policy had used the discount rate wisely. Bank rate was raised much too slowly during the boom, and lowered too late and too slowly during the slump. The rate ought to have been at its present level months ago, and to-day there is as much justification for a 2 per cent. rate as there was in the years following the Baring crisis. In times such

as these, when our currency is inconvertible, and exchange far away from the level regarded as the ultimate goal, the discount policy of the Bank of England cannot be operated satisfactorily if those in control fix their attention primarily upon the volume of currency and bank deposits, the reserve, and the premium on dollars. They must remember that it is their duty to endeavour to prevent booms and slumps, and to keep the standard of value as stable as possible. Since the Armistice, with this object in view, they should have regulated the discount rate in accordance with the direction and rate of change of the internal commodity price level.

The Federal Reserve Board of the United States has made the same mistake, though for rather different reasons. The policy of the Board has been very ably criticised by Mr. Hawtrey in a paper read to the Royal Statistical Society last month. "The whole world," says Mr. Hawtrey, "has been plunged into the most appalling distress for nearly two years by the strain of raising the commodity value of the dollar 80 per cent." I agree with him that this was unnecessary, and that it was due to a failure on the part of the responsible authorities to understand what he calls the vicious circle of deflation. If he were not an Assistant Secretary of our Treasury, Mr. Hawtrey might have extended his criticism to the policy of those in control in this country, for we need not be dragged at the heels of American error.

This past history is important, because it throws some light upon the mentality of those responsible for dealing with the present and future problems which are the main concern of this paper.

Bank rate in London is now (27th February) 4½ per cent., the rediscount rate of the Federal Reserve Bank of New York also 4½ per cent., and the New York-London exchange 4.42. I have said that in my view Bank rate ought to be 2 per cent., and that London need not wait for American reductions. On the contrary, the rapidity of the recent rise in sterling is a very strong reason for putting London rates below New York rates. The rise is harmful to our trade, and we ought to check it, not stimulate it. If we are to aim at restoring the pre-war parity with the dollar, let us stimulate the rise in sterling when trade is booming, not when it is in the depths of depression. We can more easily afford to check a boom than to knock trade on the head when it is trying to get on its feet again.

I do not propose to discuss the question of devaluation. At present the discount on sterling is being so rapidly reduced that the restoration of the old parity appears within easy reach, but in a few months' time the rate may fall away again, and devaluation may in the end become desirable, if not inevitable. If we were to attempt to stabilise sterling immediately we should have to devalue, but, an immediate choice being unnecessary, all we need do is to make up our minds not to damage our trade by a financial policy designed to restore the old parity at an early date.

The problem of maintaining exchange stability is quite different from the problem of fixing and attaining the level at which stabilization is to be attempted.

There are, in my opinion, three important preliminary conditions of an attempt at stabilization :—

(1) A practicable settlement of the Reparation and Inter-Allied Debt problems.
(2) A reduction in the size of the favourable trade balance of the United States, and the maintenance of this reduction for a considerable period.
(3) A restoration of complete confidence in the ability and determination of our Government to balance the budget.

With these fundamental political and economic obstacles out of the way, we could turn our attention to the technical aspects of a difficult, though not impossible, problem.

The technical difficulties will probably prove greater than is generally expected, and it is essential that they should receive careful consideration before we take the plunge.

The account of this country with the rest of the world, is balanced to a half-penny every day. If there is anything owing either way after the payment of all debts arising out of sales of goods, services, gold, currency notes, and securities, the difference is settled by an international credit in the books of bankers. It is true that the attempts of debtors to settle the difference, or, in other words, to secure exchange which does not exist, cause exchange rates to move, and this movement not only alters the money figure of the old debts which are being settled, but also causes an offset by way of new sales of goods, services,

gold, notes, and securities within the day. Thus, in two ways a shift in exchange rates reduces the difference which is left over for settlement by bankers, but, in spite of this reduction, the final amount is at times a large one.

Before the War, seasonal and other temporary fluctuations in exchange were confined within the gold points, and the fact that they were so confined, though due primarily to the guarantees of the gold standard, was due, secondarily, to the willingness and ability of international bankers to settle the difference referred to above. But it must be remembered that any grant of international credit involves the creation of an open exchange position, and that bankers, as a rule, are unwilling to run the risks of heavy losses in exchange. Before the War, bankers settled the final difference, because they considered their risk of loss to be confined within the limits of the gold points. If we restore the gold standard, they will not shift balances for small exchange and interest rate profits, unless they have complete confidence that the attempt to maintain exchange within the gold points will succeed. Since the Armistice the banks have been able to settle the final differences in spite of fluctuating exchanges, because the necessary speculations in exchange have been made by other people. In fact, under present conditions, the initiative in settling the difference and checking an exchange collapse is taken by exchange speculators, the banks being now mere agents in the matter. If there were no people willing to speculate in exchange, the required credits would not be granted, and the exchanges would collapse. When we restore the gold standard exchange speculators will go out of business, and the burden of taking the initiative and acting as principals, will once more fall mainly upon the banks.

It is further to be noted that the final difference must not be too great for the credit granting capacity of the bankers, and we cannot assume that the daily adjustments required will now be as small as they were before the War. For both political and economic reasons, the trade disturbances are likely to be greater, and the assistance given by the movement of securities is certain to be less, partly because the credit of many borrowers is impaired, and partly because, with taxation at its present level, double taxation is a very serious barrier to the transfer of securities from one market to another.

I, therefore, conclude that it will be very dangerous to attempt stabilization until we have assured ourselves both that the task of adjusting the daily balance is not beyond the capacity of bankers, and that the prospects of success are so obviously good that the whole banking world will feel confident about the result.

Another difficulty is caused by the large volume of Treasury Bills outstanding in this country. The machinery by which the Bank of England controlled the exchanges before the War would now be much less effective, because holders of Treasury Bills can force the British Government instead of foreigners to make good the deficiency in the reserves of our Money Market. The difficulty cannot be overcome quickly by funding Treasury Bills, because Treasury Bills are now an essential element in our internal currency and banking system, and their elimination can only be effected at the cost of heavy and harmful deflation. So long as there are Treasury Bills in the hands of the public and the Joint Stock Banks, the Bank of England will have to make very rapid and drastic changes of the rate of discount in order to produce any effect upon the foreign exchange position, and even so I very much doubt whether the discount rate will prove adequate. Some new device may have to be summoned to our aid.

A third difficulty may arise if the debts owing to our Money Market by foreigners are different in size or type from what they were before the War. Under pre-war conditions the rapid protection which we sometimes required for our gold reserves was supplied mainly by calling these foreign loans. If such loans are now smaller in volume as compared with our normal daily foreign account, or, though as large in volume, of longer average maturity, it is obvious that they will be a less effective instrument than they were for protecting our gold and correcting the exchanges. I am not able to express any decided opinion upon our present position in this respect, but I think there are good reasons for suspecting that the strength of our foreign claims portfolio has decreased. It is, in any event, a question which requires very careful consideration.

We must also remember that foreign claims upon us are more important than they were before the War. In 1914 prac-

tically the whole world with the exception of France owed us money on balance on short loan contracts, and the United States were at our mercy when we called our loans at the outbreak of war. To-day the United States are in a very different position, and the task of protecting our gold would be extremely difficult if they were to call the loans which they have made to other countries.

A fourth difficulty is provided by the uncertainty as to the sufficiency of the world's gold stock for the support of the present volume of currency and credit measured in terms of gold. The world's stock will certainly not suffice unless all countries use gold very economically. It is, therefore, very unwise to suggest, as the Chancellor of the Exchequer has done, the possibility of a resumption of the use of a gold currency in circulation in this country. If we want to have a free market for gold, we must devise some plan for establishing such a market without allowing gold coin to return to the pockets of the people. The alternative to economy in the use of gold is a further severe fall in commodity prices, a disastrous solution which should be avoided at almost any cost.

We have discovered during the last few years that the welfare of the whole community depends very largely upon monetary policy, but, in spite of this, it is hardly an exaggeration to say that we now have no policy at all. The pre-war policy will not work under post-war conditions, the Cunliffe Committee Reports provide little guidance in our present troubles, and we are, therefore, leaving everything to the Treasury and Bank of England, who are better fitted for the work of operating an old policy than for the very different task of devising a new one. We are sailing uncharted seas, and at each stage of our progress we need the guidance of men whose ideas about money extend beyond the narrow limits of pre-war inductions. It is above all things essential that our problems should be submitted to a fresh committee on currency before we attempt a return to the gold standard. If this is not to be, then may Heaven deliver us from the Norman Conquest of $4.86\frac{2}{3}$.

DISCUSSION.

THE CHAIRMAN (Sir Robert Molesworth Kindersley, G.B.E.) said that when he was asked to take the chair the subject given to him was "Certain Aspects of the Problem of Exchange Stabilisation." That was a very wide problem indeed and might embrace other problems of exchange which would be just as difficult as the question of sterling dollar exchange only. Perhaps the author might have thought he would be able to draw him to do battle on the occasion on behalf of the Bank of England, but if by any possible chance that was the author's idea, he was afraid he would be disappointed, because as the paper had taken rather a personal turn in regard to the Bank it was not possible for him, as a director of the Bank of England, really to enter the lists in a serious way. He did not intend to do so because, if he did, he might be considered to be interpreting the views of his confrères in the Bank and he did not wish to be considered in that light He was like the gentleman who, when threatened by the Blackhand gang in New York, that if they did not receive 20,000 dollars they would murder his wife, wrote back and said he could not possibly give them 20,000 dollars because he had not got them, but their proposition interested him! He thought that was really as far as he could go: the proposition interested him. He did not agree with the author in his statement that the American situation could be entirely disregarded by this country; nobody who was in a responsible position could adopt such an attitude On the other hand, the author had stated that the Bank rate might just as well be 2 per cent. as $4\frac{1}{2}$ per cent. To such lengths he did not go, but he would like to state what he had felt for a very long time that probably one of the most important consequences of the war was the extraordinary loss of the sense of proportion in every walk of life. In considering what was dear money and cheap money the world had really lost its sense of proportion. People were inclined to think money was cheap when they talked of $4\frac{1}{2}$ per cent., and so it was but only by comparison with the previous high rates, but the sense of proportion in regard to that particular matter had suffered in the same way as with regard to other things. He disagreed with Mr. Falk with regard to the American situation, feeling that the American rates must to a large extent govern the London rate. It was necessary not only for this country to get back a sense of proportion in regard to what was cheap money and what was dear but also for America to do the same. It was necessary for both nations to march along the same road. The paper had taken a somewhat personal turn so far as the Bank was concerned, and as a Director of the Bank he preferred not to deal with the subject in detail.

MR. F. E. STEELE said the Chairman had taken the line of the Scotch Minister who when faced with a theological difficulty said "We will look this difficulty boldly in the face, and pass on." He did not see how the Chairman, having regard to the position he occupied, could take any other line than that he had taken, however.

The fact remained, though, that before the bank rate was raised to 7 per cent. prices were rising rapidly in every direction and there was a regular orgy of speculation. Thursday after Thursday went by without the Directors of the Bank of England taking a step which would have checked some of that speculation and the undue rise in the price of commodities and so saved some of the misery which had since occurred through things collapsing. The Bank of England had in its hands a machine devised to check such evils, and that machine should have been used earlier. The raising of the Bank of England rate was like the red light which showed danger and the moral effect of raising the rate was important. Then, too, the high rate was kept on too long, being retained when prices fell. When the bank rate was maintained at a high level for an unduly long period it constituted a handicap on industry which was unnecessary and indefensible and on those points he very cordially concurred with the line that Mr. Falk had taken. There were three conditions of stabilisation given in the paper, one being that the reparation problem must first be got out of the way. What had to be settled was the amount to be paid, the method of payment and the division of the money among the various claimants. The last point had been emphasised during the last few days by the American claim. In all discussions about currency there was talk about the desirability of balancing Budgets, a very necessary thing, and about stopping the printing press, an equally desirable thing: he was absolutely convinced that until the question of reparation was settled on the lines indicated there would be never any stabilisation of exchanges It was a point to which the earliest attention of the Government and of financial authorities should be directed.

SIR LANCELOT HARE, K.C.S.I., C.I.E., felt that not sufficient attention was given to the fact that as prices rose purchasers found their incomes insufficient to purchase and were bound to hold off buying and consequently traders and manufacturers had to consider whether they should hold on and compel people to have things at a high price or face a loss and continue to pay interest to their bankers or have their loans called in. Therefore, when people spoke of the bank rate causing deflation they were sometimes rather in the position of the fly on the wheel. The banker might think that by increasing the rate he was causing—and in a measure he was—prices to fall, but the main thing was that if the quantity of money was constantly being increased, prices were forced up without increasing the incomes of all the people. He had written a little book on the study of exchange ["A Study of Exchange," P. S. King & Co., Orchard Cross, 2s. 6d.], which he believed contained a true theory of currency. The old economists had always argued from experience, and had said that currency was a medium of exchange and standard of value, but taking it synthetically it was quite easy to see that the currency could be enormously increased without increasing permanent incomes. A man promised £1,000 a year 20 or 30 years ago was now only getting the equivalent of £200 or £300, and sufficient attention was not paid to that part of the case. He thought the true solution was to be found in a proper system in which gold would be the coin but not at its full value, that the gold in the coin should be always less than the value of the coin for purchasing. Eventually it would be possible to work up to a system which was the aim of the old economists, that the value of currency should be fixed on the average of a great number of commodities, and not only upon gold. It was essential to get back to gold in currency and values must be at such a standard that the great mass of people whose incomes had not been raised should be able to purchase as they did before the war.

MR. CHARLES SELIGMAN said Mr. Falk had stated that Treasury Bills were to-day a necessary part of the banking outfit and that therefore he did not like to view the possibility of a repeated reduction of those Treasury Bills by too quick deflation. Would not that be entirely met if, on the revival of trade, Treasury Bills were replaced by the genuine trade bill, which was what the bankers wanted? Automatically the Treasury Bill would disappear as the trade bill took its place. With regard to the question of gold, the author had stated that it was a question in his mind as to whether there was sufficient gold in the world for the requirements of the world under the new conditions. Was it possible that something other than gold could have the functions of gold? During the process of reconstruction would not approved bills or approved securities deposited with the bankers do the work of gold until such time as the gold of the world had been redistributed amongst the countries in proportions necessary for those countries' work?

MR. ALFRED RORKE asked whether it was necessary or possible to re-introduce gold currency. Was not the main cause of the difficulties in exchange the fact that artificial wealth had been created by the banks of Europe and that all the difficulty was caused in the endeavour to justify that artificial wealth?

MR. CHARLES GANE asked the author if he could explain precisely what was meant by devaluation.

MR. FREDERICK WIGGLESWORTH said there was great necessity for a low bank rate for the export trade. Money was borrowed in this country by our foreign and colonial friends, and remitted in the form of goods, and thereby

trade was stimulated: and from that point of view it would be a great advantage to the country to have a rate lower than that of New York. America had all the resources to supply her own people with everything they required and was practically independent of export trade, but England could not live without export and if she modelled her monetary policy on that of New York she was almost bound to suffer in the competition. He ventured to suggest that it was possible to maintain stability of values, at least temporarily, without reference to gold, by maintaining internal values in this country as constant as possible and regulating the movement of the rates for money accordingly. The effect of the bank rate was much more to contract the velocity of circulation than actually to deflate. As a matter of fact the bank deposits were practically as large as they were when the bank rate was put up to 7 per cent, but what happened was that the whole position became solidified, and it was not until the rate was lowered to 4½ per cent. that the position began to liquify, causing money to flow into the Stock Exchange. Gradually that money would find its way into the trade of the country, and thus restore industry.

Sir Henry Strakosch thought the importance of the bank rate policy of the Bank of England and the Federal Reserve system could be exaggerated, especially during the period which followed immediately the Armistice. The whole system of production, distribution and consumption suddenly changed from one of war to peace. There were huge stocks of certain commodities accumulated while other commodities were scarce, and there was a difficulty of intercommunication with the various countries so that merchants could not gauge the situation as in normal times. Then came the phenomenon which followed all wars—huge stocks of commodities held up by Governments, merchants and speculators, assisted no doubt by bank credits. The rise in prices which took place after the Armistice was almost inevitable and the slump which followed was equally inevitable. Forced sales had to take place. Whatever the bank rate had been in those days there would have been a glut of certain goods and a very severe slump. Then there was the complete loss of equilibrium in prices and wages. The wage level was far too high at that time to be able to replace what was consumed. Hence too curtailed production in many industries! Wages had to adjust themselves to the new price level before the wheel could start to turn round. That was a phenomenon witnessed from early in 1919 until the middle of last year. He very much doubted whether the money policy of the Bank of England or the Federal Reserve system could have changed very materially what had taken place.

Mr. Cecil Brown asked whether Mr. Falk did not think that the collection of gold in America was not, to a certain extent, affecting the stabilisation of exchanges. Was there any prospect, by trade or otherwise, of the enormous collection of gold, about two-thirds of the gold of the world, being distributed so as to stabilise exchanges? A short time ago when he was in America the industrial population hated the very sight of the gold that was stored up; it was doing nothing to earn money. Could not the nations who had paper currency have a certain amount of gold reserve against that paper currency?

Mr. Geoffrey Marks said the suggestion made in the paper that a fresh Currency Committee should be appointed to consider the problems which came before the Cunliffe Committee in the light of existing conditions was one of the most important that could be possibly put before the Government, and he did not understand why the Government had turned down the suggestion. He thought it was perhaps the most important method that could be devised of discovering the necessary solution.

Mr. M. Kipp drew attention to the very great improvement in the question of exchange since the Armistice. The eastern exchanges and the exchanges with the Colonies were beginning to function more normally and between the limits which existed before the war. The great fluctuations nowadays were in the American dollar exchange which reacted on the Continental exchanges and no stabilisation of the one was possible without the stabilisation of the other. A condition precedent to the return of the gold standard and the free exchange of gold was some arrangement with America for the funding of the present debt; otherwise America would be able to call in the whole of the gold as we accumulated it He did not think the proposal to have a new Committee on Currency was a good one The Committee on the Indian Exchange, he believed, was totally wrong in its findings. The question of currency was best left to find its own level guided by the rate which the Bank of England stated. If the Bank of England moved with prudence it was very much better than moving with too much haste.

Mr. F. H. H. Simpson said one of the great difficulties in approaching the question of stabilisation was that it was necessary to stabilise the whole of Europe and America and not Great Britain only. During the war this country was paying a great price in order that Europe might obtain its dollars cheaply; Europe had to pay a greater price for what she required from America. The most extraordinary thing was that the play of financial affairs had brought the return of the dollar nearer to the value of sterling. The more one thought of the question the more one was forced to come to the con-

clusion that it was only by natural forces and not by anything artificial that we could get back to the stabilisation within the old original limits.

Mr. A. F. E. Foucar considered that the main cause of the present troubles was lack of production. The law of supply and demand could not be violated. The buying power of a large proportion of the world had been enormously cut down, if not in many cases entirely eliminated, and that meant that the whole basis of international commerce, the exchange of one commodity against another or against services rendered, was nullified, and until the whole world settled down to work it was not possible to expect any real improvement in exchanges. The present state of the exchanges was merely a symptom of the disease from which the whole world was suffering. The eight hours day was an important factor in curtailing production on the one hand and the power of absorption on the other. Until people had realised that we had mortgaged the future by enormous issues of paper and that it was only by hard work we could get right, no real improvement could be anticipated With regard to the bank rate, he thought people were a little apt to overlook the fact that the raising of the bank rate did not have the effect that it had in pre-war days when there was a free market for gold. Money was thereby attracted to this country and the exchange consequently moved in our favour

Mr. Falk, in reply, said it was very difficult to say anything about the Chairman's remarks The one criticism he had made was that he did not think the suggestion that the United States could be disregarded was a sound one At present America had tremendous reserves of gold and was unwilling to use them and she had pursued during recent months a policy of deflation which had been extremely harmful to the world. If we attached more importance to 4.86¾ than to the condition of our trade we should follow in America's footsteps If on the other hand we thought more about our trade than about reaching the old parity he believed we should disregard what America did, and having our eyes mainly on our own prices we could well afford to bring our money rates below those of America. He was not sure it would have such a harmful effect on the exchanges as some people supposed The Chairman apparently thought that money in the United States might be cheapened, and therefore agreed with the criticism in the paper, in so far as it was a criticism of the use of the discount rate in the two countries. He quite agreed with Mr Steele that the reparation question and the inter-allied debt question were of first rate importance. He did not quite follow the whole of Sir Lancelot Hare's argument but understood one of his points was that the paper did not deal with the fundamental question of the economic or social advantages of rising, falling or steady prices. He had more or less assumed as a major premise in the paper that steady prices were better than fluctuating prices. He agreed that in theory, use might be made of index numbers for the purpose of the standard of value, but it seemed to him an Utopian suggestion which could not be put into operation at present. With regard to Mr. Seligman's point about Treasury Bills, he certainly hoped that in the course of time Treasury Bills would be replaced by Trade Bills. His point in the paper was not so much that Treasury Bills could never be eliminated but that to do it quickly was an impossibility It was impossible suddenly to create a mass of Trade Bills to replace Treasury Bills, and therefore, Treasury Bills could not be abolished by funding because what was put in the place of the Treasury Bills would not be a satisfactory substitute from the point of view of the banking system. With regard to the question of gold sufficiency raised by Mr. Seligman, he agreed that the difficulty might be overcome by replacing gold in part by bills. In fact one of the main points in the paper was that if we were to return to the gold standard we must economise in the use of gold There were difficulties in devising new financial machinery for economising, and it was very undesirable to contemplate a return to pre-war practice in the matter of gold currency, which was the very reverse of the economy of gold. With regard to the question asked by Mr Gane as to what was meant by devaluation, he meant by that giving a new and lower legal gold value to paper currency. A very important point was raised by Mr. Wigglesworth which went to the root of the discount rate policy, when he said he thought the main feature of the recent slump on the money side was a decrease in the velocity of circulation. That was absolutely true and most writers on money had not hitherto dealt satisfactorily with that point. They had allowed for the velocity of circulation in the quantity theory equation, but had not pointed out exactly what happened in a slump to the bank deposits. The deposits in this country had remained more or less constant for some time, but the advances had declined—in other words the inactive deposits were growing.

It was curious that people who defended the maintenance of high rates for money pointed to the fact that the deposits were not going down and claimed that as the amount of money was not decreasing rates must be kept up. That was a statement only in a slightly exaggerated form of the basis of the discount rate policy of the Bank of England, which looked much too much at the static position, at the reserves, as compared with deposits, and at the absolute level of the rate of exchange. If the Bank took account of the volume of

inactive deposits they might deal with the situation differently. Sir Henry Strakosch had criticised the fundamental premises of the whole of the argument with regard to interest rates by suggesting that too much attention had been paid to the effect of interest rates. Sir Henry approached the subject mainly from the commodity side and there was a great deal in what he said—accumulation of goods, no buyers, and a slump. But those who believed in the efficacy of interest rates thought that both on the rise and fall of prices a change in the rate made a good deal of difference The press and economic literature during the recent boom suggested a scarcity of commodities right up to the slump, but as soon as the slump came it was discovered that everybody had been accumulating goods because prices were continually rising and people expected to profit. If the rate of interest was raised the cost of carrying the goods became greater, and it had some effect. During the slump if interest rates were greatly reduced it would tempt those who were inclined to be bulls and accumulate commodities, and at such times bulls were desirable. The danger now was not a superfluity of goods but a future shortage. Mr. Cecil Brown had referred to the question of the gold in America, which was a very difficult problem. America said she did not want inflation, that she had a tremendous stock of gold, and that to prevent her people using it she would keep interest rates up. If the only way in which credit based on that gold could be used was for internal purposes there was a good deal of reason in the argument, but it was correct to say that if on the basis of that gold they were to grant foreign credits there would not be an equivalent rise in internal prices The American difficulty arose from their inability as much as their unwillingness to grant foreign credit, an inability due to lack of familiarity with that business. He was glad Mr. Marks had supported his appeal for a fresh Currency Committee because he attached a great deal of importance to it. Mr. Kipp thought it would be a great mistake to have such a Committee because Committees were always failures. If the Cunliffe Committee was a failure—as he thought it was—it was one of the strongest reasons for having another one which could not make the position worse and might make it better. The report of the Cunliffe Committee was said to be the bible of the Bank of England, and there was the chance that another Committee might induce the Bank to change its religion. If he had understood Mr. Simpson correctly, one of his main points of criticism was that the paper condemned the Bank for basing its policy on pre-war custom and theory, but at the same time asked the Bank to use its discount rate policy in the way in which it was used before the war. Mr. Simpson imputed to him a wish which was not his, for he should criticise the use of the discount rate policy by the Bank as he criticised its use now. The use of the rate before the war was more successful because while the country was on a gold basis and conditions were more stable the rule of thumb adopted by the Bank led them, as he thought accidentally, more or less along the right track. They looked at the wrong things but those things led them right. To-day they looked at reserves and reserves had become useless as a criterion and they looked at the exchanges and no one knew what the real parity was. He believed that if the dollar rate was above 4 and rising it was a very good reason for having lower rates in London than in New York

The Chairman, in proposing a vote of thanks to the lecturer, said Mr. Falk had been somewhat disappointed that he did not give him anything to catch hold of--but that was his object; he did not intend to be drawn to do battle on the present occasion. He was sure everyone had learned a good deal from the paper and discussion in regard to such an interesting question. He thought that if Mr. Falk were a member of the Court of the Bank of England he would find that he attributed to the Members of that Court a great many sins for which they were not really responsible and a great many ideas and decisions of which really they were entirely innocent.

The motion was carried unanimously

A vote of thanks to the Chairman concluded the meeting

CHEMICAL RESEARCH FOR KEY INDUSTRIES IN INDIA.

In an article in a recent number of the Journal of "Indian Industries and Power," Mr. E. R. Watson, Principal, Research Institute, Cawnpore, points out the urgency of particular chemical researches most likely to lead to important industrial developments in India. In discussing this, he considers, first, a wider question, namely, what industries, involving chemistry, are most capable of development, or likely to develop in this country. The two problems are not synonymous, as there may be industries involving chemistry which are capable of large and successful development in this country, without the assistance of chemical research, or with very little assistance. Again, this second question, as to what industries, involving chemistry, are capable of development, is evidently part of a still wider question, viz., that of the industrial development of India as a whole.

Government's Work.

The chief contributions which have already been made to this subject should first be mentioned. The United Provinces Government

was early in the field, as in 1907 it considered the establishment of a technical institute at Cawnpore, of which one of the main functions was to be an investigation as to what chemical researches were most urgently required and most likely to be useful. It is satisfactory to note that the institute has now materialised.

The Industrial Commission's report (1918) has a chapter on the deficiencies in Indian industries. It points out the order in which industries have developed in other countries, viz., iron and steel manufacture first, then the production of textiles and similar goods by machinery, then the manufacture of chemicals required in these large scale industries. It also draws attention to India's deficiency in iron and steel production which has retarded the proper development of many industries dependent on machinery.

Drs. Sudborough and Somonsen have discussed chemical industries in the late Indian Munitions Board's Industrial Handbook (1919.) They there laid down the general principle that in any attempts to foster the development of chemical industries in India, attention should be directed, in the first instance, to industries which make use of the Indian-grown raw material now exported to other countries. Included in these exports are (1) the raw materials from which important fixed oils and feeding cakes are manufactured; (2) the raw materials from which valuable essential oils and medicinal drugs are prepared, and (3) various mineral products, such as chrome, manganese and zinc ores, wolfram and monazite sands. It is, however, admitted that the proposition of making India an oil and oil products exporting, rather than an oil seeds exporting, country, is not a simple one. In addition to industries, it is recognised that the manufacture of heavy chemicals is a key industry or group of key industries; and, as to their prospects, it is considered, firstly, that the manufacture of sulphuric acid for some time to come can be suitably obtained from Indian nitre (the utilisation of atmospheric nitrogen is considered to be a proposition requiring careful consideration), and, thirdly, that it is doubtful whether sufficient soda to meet all Indian requirements can be obtained by the extraction of alkaline soils. The cost of the ammonia soda process would probably be too heavy to permit of soda manufactured by this process competing with imported carbonate in normal times. The electrolytic production of caustic soda and soda ash could only be made a success by utilising the by-products, and Magadi soda is likely to be a dangerous competitor with the Indian manufactured article; but, nevertheless, alkalis are so important that it may be necessary to protect their manufacture. It is considered essential to manufacture chlorine and bleaching powder in India.

As to manufacture of explosives, synthetic dyes, drugs, etc., from coal-tar, it is considered that the amounts of tar available in India at present are quite insufficient to start a large coal-tar industry, and that the only way to start such an industry would be to coke all suitable coal at the pit head.

The manufacture of permanganates, chromates and lead products, such as litharge, red lead, and white lead, are all considered to be eminently practical propositions.

Wood distillation is regarded as rather a doubtful proposition, owing to the existence of large supplies of its products and the low prices likely to prevail for some time after the war.

The Indian Munitions Board held a conference of chemists in 1918, and organised, as far as possible, chemical research work on industrial problems. Their list of chemical researches which have been taken up, includes very little under the head of heavy chemicals; it includes a good many researches on Indian oils, such as neem, mahva, til, fish oils, the hardening of oils, the manufacture of glycerine and varnishes, the utilisation of new Indian tanning materials and preparation of tanning extracts; the preparation and refining of essential oils, such as rose, patchouli, retivert, lemon-grass, clove, cardamom; the manufacture of strychnine, atropine and caffeine, the manufacture of chromates, wood distillation, and various problems which are not touched on in the chemical industries article in the handbook, such as the manufacture of starch, alcohol and glue.

The Chemical Services Committee (1919-20), have expressed the opinion that India is deficient at present in raw materials for the production of organic chemicals from coal, but consider that there is an enormous field for the production of carbon compounds from vegetable products. They explain that they do not only refer to such products as oils from oilseeds, indigenous dyes, drugs and essential oils, but consider that there is a great field for the production of new products of greater economic value by the conversion of organic compounds present in Indian plants.

Sulphuric Acid.

Owing to the importance both of sulphuric acid and zinc, the Government of India is interesting itself in the proposal to erect zinc-smelting works at Jamshedpur, where the zinc concentrates from Bawdin in Burma will be dealt with, and the spelter and sulphuric acid yielded made available to the Tata Iron and Steel Company for their own purposes and for subsidiary companies. The plant, which it is proposed to erect, with a loan from Government, will be capable of dealing with 25,000 tons of zinc concentrates, and the estimated output is 10,000 tons of spelter per annum, and 32,000 tons of sulphuric acid. The iron and steel industry requires large quantities of sulphuric acid for recovering

ammonia from the coking plant, and for pickling iron palte for galvanising and tinning. Most countries consume very large quantities in the manufacture of superphosphates. There is no reason to fear that the production of sulphuric acid will exceed the demand, but it should meet all requirements for some time, including requirements for the manufacture of explosives and dyes.

NITRIC ACID.

At present, India exports about 26,000 tons of nitre, consumes about 4,000 tons, and imports about 1,700 tons of Chili saltpetre. Her imports of nitric acid are negligible. With a sufficient supply of sulphuric acid there will be no difficulty about producing the nitric acid required for explosives and dyes.

CAUSTIC SODA.

The quantity of alkalis required for the manufacture of dyes and explosives, is comparatively small, and India's requirements in this respect could easily be met from the salts contained in alkaline soils. That it is a key industry there can be no question. The present consumption of alkalis is comparatively small (35,000 tons of soda imported in 1917-18), but increased production of cotton goods and soap is bound to multiply many times the present demand for alkalis. An increased demand for cotton goods is one of the most certain results of India's development, and with an increase in the production of iron and steel machinery, there is no doubt that increasing quantities of cotton goods will be manufactured in this country. The present value of cotton goods consumed per head of the population is Rs 2-12 per annum There can be no doubt that this will be multiplied several times in the near future, and that the bulk of the goods will be manufactured in this country. This will increase proportionately the demand for alkalis, which are used for scouring cotton goods.

ALCOHOL.

As India is essentially an agricultural country, and exports large quantities of material such as grain, which are used in the country of destination for the production of alcohol, there seems no reason to doubt that industrial alcohol could be successfully produced in India.

Problems are certain to arise from the fact that the materials available, or climatic conditions or other factors, are different from those in the countries already carrying on the manufactures referred to above. These are platitudes which the British find hard to recognise, but which are, nevertheless, recognised to a greater extent than before the war. Apart from the fundamental industries there are others which are not, perhaps, of such vital importance. In others, there are any number of chemical problems appealing, perhaps, more strongly to the chemist, whose interests are primarily scientific, e.g., lac-dye is thrown away at the present time. Again, in Indian turpentine we have a cheap source of pinene in any quantity The chemical relationship between the different members of the terpene group is very close, and it seems quite feasible to convert pinene into the unsaturated open chain compounds.

THE CULTIVATION OF TOBACCO IN JAVA.

Tobacco is cultivated in Java (1) by natives working independently of foreign supervision; (2) by natives under the supervision of European companies; (3) by European planters, who lease the land from the natives, hiring them to work; and (4) by European companies who lease large tracts of land from the sultans and princes. According to a report by the United States Trade Commissioner in Java, the cultivation of tobacco by the natives of Java, like most of the native agricultural effort, is carried on with no conscious effort to improve the quality of the produce, the consensus of opinion being that such differences in quality as exist in the native production are due to the influences of the climate and soil. The cultivation of tobacco under the supervision of Europeans is centred in the residency of Bezuki, in eastern Java, and in the Vorstenlanden, which includes the principalities of Jokjokarta and Surakarta in the southern part of central Java. While the general process of cultivation is the same in both districts, the conditions of climate, soil, labour, and land tenure are not the same, and the product is of different qualities, although both find a ready sale in European markets

The preparation of the soil for the cultivation of tobacco begins in April, as soon as the rice crop is off, and the land is turned back to the natives by January 1st The tobacco companies in the Vorstenlanden, who lease the land from the sultans and princes, receive a rebate on their rental if they turn the land back before that date, and are subject to a heavy fine if they hold it longer. The rotation of crops includes one crop of tobacco from April to December, and three rice crops, requiring from four to five months to mature, making 24 months in all. In Bezuki three crops of rice are not usually possible, and one crop of maize or beans is substituted.

In the official customs returns for 1916 and 1918 the exports of tobacco from Java are listed under three grades, as follows: (1) Leaf tobacco, which is grown only by the estates under European control, is either consigned to the estates' agents in the Netherlands or sold direct by the estates. American buyers visit the principal centres yearly to make selections of this variety, the "American assortment" containing only the largest leaves of fine texture and light colour. (2) "Krossak," or scrubs, is leaf tobacco of grades lower than wrapper tobaccos. It is mostly of native cultivation

and is graded very exactly according to size, texture and colour. (3) "Gekorven" is a stripped and cut tobacco, made up of leaves that will not go into the "krossak" grades to good advantage, but are of fairly good quality There is considerable labour attached to its preparation, which accounts for the higher price at which it is appraised by the customs. It is used by the natives, and when exported goes either to the Netherlands or to the near-by countries.

Within these grades there are many subdivisions, so that there are literally hundreds of grades known to the buyers. The above grades are qualified, as a whole, by the district in which they are grown, the principal varieties being the undermentioned.

Madura tobacco, which is grown on an island of the same name east of Java, stands as high as any in the "krossak" grades. The superior quality is due to climatic and soil conditions. During the past few years it has brought better prices than formerly, as some of its grades are desirable for the manufacture of cigarettes

Bezuki tobacco is among the best of the scrubs Besides the native cultivation there are large estates under European control which produce the finer types of leaf tobacco

Loemadjang tobacco takes the name of a town in the eastern part of the residency of Pasuruan at the foot of the south-eastern slope of Smeru Mountain. The quality of the tobacco raised here ranks with that of Madura and the lower grades of Bezuki

Malang tobacco comes from the district lying east of Smeru Mountain, the centre of which is the town of Malang. The elevation of this land is somewhat high and the quality is poorer than the above named tobaccos, which is undoubtedly partly due to climatic differences

Kediri tobacco is grown on the lower stretches of the Kloet and Willis Mountains. It ranks with Malang tobacco, among the poorest of the scrubs.

Rembang tobacco is grown in almost every part of the residency of that name. The bulk of the "krossak" going through the Soerabaya market comes from this district, and it is of the lowest grade.

Kedu tobacco, grown in the residency of Kedu, is of a quality between that of the first-named group of those of Rembang, Kerdii, and Malang. The better grade produced here is attributed to a favourable climate and soil and to better seed being used.

Soerabaya is the principal tobacco market for Java. Much of the tobacco is drawn to this port by the superior warehousing facilities and by the speculator market. The port also has advangates in transportation over the port of Samarang in handling the tobacco from Kediri, Malang, Loemadjang, Bezuki, Madura, and ports of Rembang, although tobacco is often shipped from the minor ports. Cheribon, on the north coast of Java, ships only "gekorven" tobacco from the Kedu district or from the small native culture in scattered patches throughout the vicinity of that port. Samarang is the port for tobacco from Kedu, the Vorstendlanden, and for a considerable part of the Rembang product

The principal tobacco district of the Dutch East Indies is situated in the East Coast Residency of Sumatra and its product is shipped principally from Belawan Deli, Medan's port, and from Tanjong Poera, Tanjong Bali, and Tanjong Tirem, secondary ports handling considerable quantities of tobacco in normal years.

Tanjong Priok, Batavia's port, is the port of export of a large part of the tobacco from southern and south-western Sumatra as well as from the Palembang district in south-eastern Sumatra. Sumatra tobacco is distinct from Java tobacco in quality and in the conditions surrounding its growth and marketing.

Before the war the Netherlands practically enjoyed a monopoly of the tobacco business of this colony, Germany, Singapore, Penang, and Hongkong being the only other countries listed as purchasers in 1913, and, in the case of Java tobacco, only for small amounts American purchases were then made in the Netherlands, but the scarcity of tonnage and marine risks brought the market to the Dutch East Indies in 1917. Shipments to the United States in this year consisted of approximately 500 tons of Java wrapper leaf, 85 tons of Java "krossak" and 1,215 tons of Sumatra wrapper leaf, while in 1918 the shipments amounted to 400 tons of Java wrapper leaf, 108 tons of Java "krossak" and nearly 1,900 tons of Sumatra wrapper leaf Figures of export for 1918 showed a general purchasing in this market from abroad.

As is the case with the sugar planters, the tobacco planters of Java believe the time to be near when they will be forced to use machinery. Experiments have been made with a small tractor of the wheel type, but it was found to be too small and otherwise unfitted for the work. A small tractor of the caterpillar type was also to be tested. The efforts of the Sugar Syndicate to get a suitable machine for use in sugar cultivation are being closely watched Success will undoubtedly have an influence on the plans of the tobacco planters.

While the problem in the tobacco fields is similar in some respects to that of the sugar planters, there are fundamental differences. The sugar planters have skilled mechanics and repair shops connected with their industry, while the tobacco planters have not. The sugar planters level the rice fields before planting, while the tobacco planters, especially in the Vorstenlanden, endeavour to preserve the contour, at least, of the rice fields. Sugar is planted in deep furrows from 4 to 5 feet wide and there is no series of successive ploughings, while the tobacco fields go through a slow preparation

for months before planting. The cultivation of tobacco requires light machines for the finer cultivation and yet the ground must be turned to a depth of 15 inches and some heavy ditching must be done.

It is suggested by the Trade Commissioner that manufacturers can assist the sugar and tobacco planters in solving their problems by sending drawings, illustrations, and prices of their machines to the proof stations, thus hastening the opening of a large market.

SOUTH INDIAN WATTLES.

By KALYAN C SRINIVASAN, M A , F.C.S.

Consulting Glue Chemist, Department of Industries, Madras.

Read before the Indian Science Congress on 3rd February, 1922).

The luxuriant growth of a species of black wattle in the high ranges and on the Nilghiris suggested the present investigation as to whether the areas would afford a valuable source of tannin, suitable either for local consumption or for export.

This paper summarises the results of an investigation of the tannin content, optimum temperature of extraction and tanning properties of the bark of Acacia Decurrens found in South India, indicates how the tannin content varies with age, and discusses the question of the wattle extract industry in relation to wood distillation in South India

PRELIMINARY EXPERIMENTS.

Analyses of a few samples of air dried bark from full-grown trees were made in accordance with the hide power method of the International Association of Leather Trades Chemists, and as worked under Indian conditions by Mr Pilgrim, Tannin Expert to the Government of India.

Except in the case of a single sample of white bark (probably *Acacia dealbata*), which gave poor results, the analyses of South Indian wattles compare very favourably with those of other countries.

ANALYSES.

	Tans.	Non-Tans.
S. Indian ((Nilghiris)	39.3 to 42.1	7.3 to 10.3
,, (High Ranges)	40.1 to 44.1	7.1 to 13.0
Natal	35.2 to 39.8	7.3 to 10.3
Cape	40.1 to 44.1	7.1 to 13.0
East Africa 11	36.7 to 42.1	9.4 to 12.7
Australia	38.3 to 49.5	4.4 to 9.4
South Australia	40.2 to 49.5	9.0 to 9.4

OPTIMUM TEMPERATURE OF EXTRACT.

The tannin from South Indian wattle barks is easily extracted and has no tendency to form phlobophanes on the filter candles. Experiments with a five-year-old bark from the High Ranges gave the following results:—

	Tans.	Non-tans.
About 32.°0 C. ...	15.1	5.3
About 65.°0 C. ...	28.2	6.1
Boiling water 100° C.	29.1	8.0

The optimum temperature is evidently somewhere about 60.°0 C. when the proportion of non-tans to tans is about the smallest and most of the tannin is also extracted.

TANNIN VARIATION WITH AGE.

This investigation was suggested by Mr Alan Guthrie, M.B.E., Deputy Comptroller of Hides and Principal, Leather Trades' School, Madras, and the samples were kindly furnished by him.

[Analyses are here given of barks from branches of trees of one, two, three, four, and five years of age, showing that the percentage of tannins in them is 18.37, 24 37, 25.97, 27.62, and 29.07, respectively.]

It is very clear from the above figures that the value of the bark increases with age. Not only the tannin increases, but the proportion between non-tans and tans decreases This latter quality is necessary for the production of a valuable extract It was also found that the thicker bark is richer in tannin than the thinner.

In the Transvaal the maximum tannin content is said to be found in the barks of trees from six to eight years old, while in East Africa, a high percentage of tannin in four-year growths is an important feature. Exudations of gum from South Indian Wattles might account for lower percentage of tannin, but the gum itself is valued at about £1 10s. per cwt. Work has still to be done using the bark of more mature growths of high range wattles

TANNING TRIALS

With calf skins, a full soft leather was obtained The leather when dried in the shade had a soft reddish tinge, a tint deeper than that obtained with Auriculata tannage, and on exposure to light, darkened visibly. The feel of the leather was very good and the leather itself betrayed no tendency to crack. The penetration of the tannin was nearly as quick as of the turved bark and is confirmed by the work of Coomba Alcock and Stelling (*Chemical Industry*, Vol. 36, page 190), who say that the wattle tannages compare very favourably with those of Mangrove, the tensile tests of the former running up to 3,200 lbs. per square inch.

UTILISATION OF SPENT BARK.

Laboratory experiments on a small scale on the spent bark of the high range wattles showed the possibility of producing about 30 per cent. of good pulp with fine felting quantities, readily bleached by SO_2 to a pleasing ash colour. It may perhaps be possible to bleach it to a clean white, but this was not attempted.

It is reported in *Chemical Industry*, Vol. 15, page 499, that spent bark contains 41.2 per cent. of cellulose, and that the length of the fibre is about 1.2 mm. But the ultimate fibres in the samples of pulp obtained above were not more than 0.8 inches in length. At any rate, very satisfactory wrapping paper of excellent quality may be made out of the pulp.

Utilisation of Wood.

The wood of the wattle tree is said to yield about 61 per cent. of cellulose and 50 per cent. of pulp capable of being used for the manufacture of straw-board.

The destructive distillation of South Indian wattle has given during semi-large trials in the Indian Institute of Science most promising results (see *Journal of the Institute*), heading the list of the South Indian woods for the value of its by-products

East African wattle gives :—

Charcoal	27.3%
Omde Pyroligneous Acid ...	48.3%
Acetic Acid	4.7%
Methyl Alcohol	1.21%
Acetone	0.24%
Dissolved Tar	5.7%
Separated	6.0%

(See Bulletin Imperial Institute, 1918, page 571.)

The ash on burning wattle is also very valuable as the following analysis shows :—

Moisture	9.80%
Combined H_2O	3.61%
K_2CO_3	8.77%
Na_2CO_3	2.10%
$CaCO_3$	77 50%
$Ca_3(PO_4)$	4 60%

Conclusion.

It will be evident from the foregoing that with the exploitation of the high ranges and the Nilghiris to their fullest extent, and the scientific plantation of most valuable species of wattles, the foundations may be laid in the near future for at least two important industries, that of the manufacture of tannin extracts and of wood distillation.

GENERAL NOTES.

Henry Saxon Snell Prize.—The Henry Saxon Snell Prize was founded to encourage improvements in the construction or adaptation of sanitary appliances, and is to be awarded by the Council of The Royal Sanitary Institute at intervals of three years, the funds being provided by the legacy left by the late Henry Saxon Snell. The Prize in the year 1922 will consist of Fifty Guineas and the Medal of the Institute, and is offered for an Essay on "Improvements in the Sanitary Appliances and Fittings for new Housing Schemes, having regard to Efficiency and Economy." Essays must be delivered on or before August 31st, 1922, addressed to the Secretary of The Royal Sanitary Institute, 90, Buckingham Palace Road, London, S W. 1, from whom further particulars may be obtained.

Trade Conditions in Amritsar - The United States Trade Commissioner in India writes that Amritsar, in the Punjab, with a population of about 150,000, is one of the wealthiest cities in north-western India It is the centre for trade with central and western Asia, and offers much business opportunity, as many trade inquiries originate there. At one time there were 4,000 looms devoted to weaving Pashmina shawls, but with the decline of this business, carpet and rug making is now the most important single commercial industry. As the centre of the Sikh religion, many pilgrims go to the city annually, visiting also the numerous bazaars which are filled with all kinds of goods. While the quantity of foreign goods appearing in the stalls of these bazaars is not as great as is found in other places, such as the neighbouring city of Lahore, a certain amount is carried in stock One of the noticeable features of this community is the extensive wearing of shoes and woollen clothes, owing to the cold winter climate.

Electrification of Norwegian Railways.—The Board of the Norwegian Engineers' Union has appointed a committee to investigate whether the time has come for electrifying Norwegian railways and whether the railways now being planned should be constructed for electric power, according to information furnished by the United States Commercial Attaché at Copenhagen

Insulator Testing in Finland.—According to the United States Consul, at Helsingfors, the Arabia Porslinsfabrik A/B, of that city, has installed a testing department with a capacity of 300,000 volts for testing high-tension material. It was built by the Allmanna Elektriska A/B in Finland, and is said to be the only one in northern Europe where tests can be effected with such a high voltage. The Arabia Co. has made insulators for the past twenty years, but not hitherto for such high tensions as are now required.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced) :—

April 26.—John Francis Crowley, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry." Sir John F. C. Snell, Chairman of the Electricity Commissioners, in the chair.

MAY 3.—NOEL HEATON, B.Sc., "The Production of Titanium Oxide, and its use as a Paint Material."

MAY 10.—MAJOR PERCY A. MACMAHON, R.A., LL.D., ScD., F.R.S., "The Design of Repeating Patterns for Decorative Work." SIR CHARLES CARRICK ALLOM in the chair.

MAY 24.—GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

MAY 31 (at 4.30 p.m.)—LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

APRIL 28.—F. G. ROYAL-DAWSON, M.Inst.C.E., "The Need for an All-India Gauge Policy." SIR ROBERT WOODBURN GILLAN, K.C.S.I., LL.B., in the chair.

MAY 26.—SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

Date to be hereafter announced:—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION.

FRIDAY, JUNE 9, at 4.30 p.m.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(JOINT MEETING.)

Friday afternoon, at 4.30 o'clock:—

MAY 5.—PROFESSOR WILLIAM HENRY ECCLES, D.Sc. (London), F.R.S., Vice-Chairman of the Wireless Telegraphy Commission, "Imperial Wireless Communication." VISCOUNT BURNHAM, C.H., in the chair.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, APRIL 24.. Building Trades Exhibition, Olympia, W., 6 p.m. Prof. P. Abercrombie, "What we Mean by Town Planning."

Electrical Engineers, Institution of (Sub Centre), The University, Liverpool, 7 p.m.

Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Graduates Section). Mr. B. A. C. Hills, "Jigs and Tools."

TUESDAY, APRIL 25.. Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m.

Textile Institute, 16, St. Mary's Parsonage, Manchester. Annual General Meeting.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Technical Meeting.

Colonial Institute, Victoria Hotel, Northumberland Avenue, W.C., 4 p.m. Dr. H. A. Tempany, "Mauritius of To-day."

Zoological Society, Inner Circle, Regent's Park, N.W., 5.30 p.m. 1. The Secretary. Report on the Additions to the Society's Menagerie during the month of March, 1922. 2. Mr. R. J. Ortlepp, "A New Species of the Nematode (*Esophagostomum* from the Rodent *Xerus setosus*)." 3. Dr. C. F. Sonntag, "On the Anatomy of the Drill (*Mandrillus leucophæus*)." 4. Dr. R. Broom, "On the Persistence of the Mesopterygoid in certain Reptilian Skulls." 5. Mr. A. Loveridge, "New Reptiles from Tanganyika Territory."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. Sir Arthur Keith, "Racial Problems of Africa." (Lecture I.)

WEDNESDAY, APRIL 26.. People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m.

Building Trades Exhibition, Olympia, W., 6 p.m. Sir Lawrence Weaver, "Modern Domestic Architecture; Fashion and Style."

Electrical Engineers, Institution of (S. Midland Centre), The University, Birmingham, 7 p.m. (N. Midland Centre), Hotel Metropole, Leeds, 7 p.m. Annual General Meeting. (N. Western Centre), 17, Albert Square, Manchester, 7 p.m. Annual General Meeting.

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Prof. D. H. MacGregor, "Industrial Relationships." (Lecture I.)

THURSDAY, APRIL 27. Illuminating Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Discussion on the Use of Light in Hospitals.

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. Prof. A. Pollard, "The Mechanical Construction of the Microscope from a Historical Standpoint."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. H. Barton, "The Resonance Theory of Audition." (Lecture I.)

Child Study, Society of, 90, Buckingham Palace Road, S.W., 6 p.m. Dr. Octavia Lewin, "The Natural Defences of the Upper Air Passages."

Electrical Engineers, Institution of, and Electro-therapeutic Section of the Royal Society of Medicine and the Röntgen Society (Joint Meeting), Savoy Place, Victoria Embankment, W.C., 6 p.m.

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. W. N. Twelvetrees, "Reinforced Concrete Piers and Marine Works."

FRIDAY, APRIL 28. Royal Institution, Albemarle Street, W., 9 p.m. Dr. A. Harden, "Vitamin Problems."

Electrical Engineers, Institution of (Scottish Centre), Technical Institute, Dundee, 7 p.m. Dr. S. P. Smith, "Single and Three-phase Commutator Motors, with Shunt and Series Characteristics."

Physical Society, Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.

Marine Engineers, Institute of, 85, The Minories, E., 6 p.m. Annual Meeting.

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W., 6 p.m. Capt. Sayers, "Some Unsettled Problems of Aeroplane Design."

Engineers, Junior, Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Capt. H. Whittaker, "Some Notes on the Utilisation of Water Power."

Mechanical Engineers, Institution of, Storey's Gate, S.W., 6 p.m. Prof. E. G. Coker, and Dr. K. C. Chakko, "An Account of Some Experiments in the Action of Cutting Tools."

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday morning of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 395.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 3rd, at 8 p.m. (Ordinary Meeting). NOEL HEATON, B.Sc., "The Production of Titanium Oxide and its Use as a Paint Material." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

FRIDAY, MAY 5th, at 4.30 p.m. (Joint Meeting of Dominions and Colonies and Indian Sections). PROFESSOR W. H. ECCLES, D.Sc., F.R.S., Vice-Chairman of the Wireless Telegraphy Commission, "Imperial Wireless Communication." THE RIGHT HON. VISCOUNT BURNHAM, C.H., Chairman of the Empire Press Union, in the Chair.

INDIAN SECTION.

The Council have appointed Lord Montagu of Beaulieu, K.C.I.E., C.S.I., a member of the Committee of the Indian Section.

PROCEEDINGS OF THE SOCIETY

INDIAN SECTION.

FRIDAY, MARCH 24TH, 1922.

SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., in the chair.

THE CHAIRMAN said he would like to explain why he had accepted the Council's invitation to preside over the meeting. The problem of natural indigo in India came prominently to his notice when President of the Industrial Commission The Commission spent some time in collecting evidence in the planting district of Bihar, and inspected the work being done by Mr. Davis and other agricultural chemists at the Pusa Institute. Some of the scientific questions involved came again to his notice in 1920, when, as a member of the Governor-General's Council, he was temporarily responsible for the Department of Agriculture. It became obvious to the Industrial Commission that after the clearing of the political fumes which were still, at that time, hanging round Tirhoot, after the Champaran riots, among the most important of the influences likely to affect the issue ot the great struggle between natural indigo and the synthetic product was chemistry, and that organic, agricultural and biological chemistry must play a predominant part in that struggle. By a rare chance, owing to the war, a chemist who had earned a world-wide reputation by his researches became inoculated with an interest in the scientific troubles of the indigo planters, and had now lent to the problem of natural indigo a fresh and original mind, working on a foundation of experience in questions connected with the development ot the synthetic substitute which was almost unique. The meeting would listen to him that afternoon not as an advocate or even as an expert witness, but as a judge who knew both sides of the question.

The paper read was:—

THE INDIGO SITUATION IN INDIA.

BY PROFESSOR HENRY E. ARMSTRONG, PH.D., LL.D., D.Sc., F.R.S.,
Vice-Chairman, Lawes Agricultural Trust Committee.

To-day I take up the story of Indigo which I began to tell to this Society on May 15th, 1919, describing work done by the Indigo Research Chemist, Mr. W. A. Davis, in Bihar, during the preceding three years. When the task was undertaken, I had in mind the composition of a triumphal march, not of a dirge; now I am overwhelmed by it and have difficulty in joining a just measure of joy with my grief. The pen of a Gibbon alone could write the oration proper to the funeral at which we are met—for such it is. The work is to be discontinued, though the inquiry has been most fruitful from the beginning and is of the greatest public consequence. I would

that the disease to which the patient succumbs could be diagnosed as the mere impecuniosity of the times: I fear it is far more grave and deep-seated—nothing short of general apathy and inability to appreciate the issues at stake, the need and value of acumen and understanding in agriculture. Yet agriculture, of all Indian industries, is beyond compare the most important; that in which considered, constant attention is most required. Indigo does not concern a few British planters alone: the problems underlying the successful cultivation of the plant are those of agriculture generally.

From time immemorial, the practice of all peoples apparently has been to grow a *leguminous* crop in alternation with a cereal or other non-leguminous plant; we have learnt, only in modern times, to appreciate its special function, that it is the means of bringing down nitrogen from the heavens into the earth; in addition, however, the leguminous plant has a peculiar value as an organic manure, especially under conditions such as prevail in Indian soils and in a country where animal fæcal manure is not available. The dyestuff indigo is, therefore, little more than a by-product; the plant residue has a high agriculture value. Moreover, the yield of plant is necessarily affected by the condition and cultivation of the soil and the produce of other crops is more or less proportional to that of the leguminous crop in the rotation, because of the treatment the soil has received and of the contributions to the soil from the plant, both during its growth and as a green manure.

Much has been done to study the growth of cereal crops but we are extraordinarily behind in our knowledge of the conditions affecting leguminous crops. Even in the case of cereals, our studies have been mainly statistical, concerning as they do the yield of grain: we have little definite information as to the influence of conditions upon quality; in fact, are not yet agreed as to the criteria of quality. Still more is this the case with leguminous crops. In studying not merely the crop-yield but particularly its quality, as measured by its indigo-giving power, Mr. Davis has taken a step forward of the greatest possible consequence in agriculture, because of the importance of leguminous crops as food materials. We have reason to believe that the nutritional value of a crop is subject to considerable variation, according to the conditions of growth; it is of utmost consequence that we should understand the manner in which such variation takes place, the more as leguminous seeds figure so largely in the Indian dietary. No other leguminous crop appears to afford the same opportunity as the indigo plant—no individual constituent can be singled out as a criterion of quality and estimated easily, as indoxyl the precursor of Indigo can be.

It is desirable to correct a misunderstanding, which seems to be current, that Mr. Davis was first appointed for a year to develop the manufacture of an indigo-paste which could be exported from India and only then appointed for a further period of five years to study the problems of indigo generally. As I was directly responsible for his appointment, I am in a position to place the facts upon record. When I recommended him and the terms of his agreement were under discussion, I was pressed to make it for five years; but I insisted that it should be only for a single probationary year. I was fully conversant with the unfortunate history of indigo; I knew that the problem was very complex and that success was not a question of mere practical and scientific ability but that the personal element would also count. When in Calcutta, in November, 1914, I had pointed out, in a letter to *The Statesman*, that it should be possible to effect improvements especially in agricultural practice, as well as in the plant itself and in the process of manufacture. I was anxious that Mr. Davis should have the opportunity of proving his fitness to undertake the great responsibility of the combined task.

The problem, *as a whole* and in all its parts, was assigned to him from the beginning; but he was advised, in the first instance, to prepare a paste comparable in form with that in which the Germans put synthetic indigotin upon the market, *i.e.*, a paste containing as nearly as possible 20% of indigotin. Incidentally, let me here again emphasise the fact that the Germans have never made *indigo*.

The immediate success of artificial madder (Alizarin), which preceded indigotin, was due almost entirely to the fact that it was supplied as a paste of definite strength; the same policy was at the root of the success of synthetic indigotin. Had the planters, when competition began, put indigo upon the market as a paste of standard strength,

I believe their industry would not have been ruined; indeed, in my letter to *The Statesman*, I wrote:—"If the advantage gained by natural indigo through the war is to be maintained, I believe it will be necessary for planters in future in some way to arrange to bulk their products and put upon the market a paste of fixed composition comparable with that supplied by the Germans."

At the same time, I expressed the opinion that it should be possible to secure a fair share of the trade for natural indigo in competition with the synthetic article. Now, I am prepared to affirm, with far greater emphasis, my belief in a secure future for indigo. Not only has it a markedly higher value, as a dyestuff, than indigotin pure and simple, but it may well happen that not a few natural dyestuffs may once more be in demand, because of the difficulty of obtaining the raw materials for the manufacture of artificial substitutes. I have long been a prophet of a time when, whatever the supply of cakes and ale, there will be little or no coal tar. We are rapidly losing patience with ourselves as smoke producers and bent on reforming our characters; even *The Times*, through the eloquent pen of Mr. Maurice Hewlett, has indulged in sun-worship of late; there are signs of our recovering this most ancient of cults by resort to smokeless fuels produced at low temperatures; a prominent representative of the most conservative of known industries has admitted this, only recently, on this platform, while smoking himself in illustration of the dangerous qualities of smoke.

But gas works are not the only source from which the raw materials of the dyestuff industry are supplied; a considerably larger quantity of coal than they use—perhaps twice as much—is carbonised at a high temperature in producing metallurgical coke, mainly for use in the blast furnace; much benzene, naphthalene, etc., is derived from this source. The probability is in no way remote, that changes may be introduced into iron smelting which will render the production of such coke at a high temperature unnecessary.

Should there be a shortage of the raw materials from which dyestuffs are now manufactured, natural colouring matters, especially indigo, will necessarily again come to the fore.

NATURAL INDIGO PASTE.

Two of the chief advantages which have always been claimed for synthetic indigotin in comparison with indigo are uniformity of colour-strength and fineness of division. It has been the custom of the makers to supply the synthetic product in the form of a paste containing 20% of dry indigotin; in this paste, the pigment is in so finely divided a state that no mechanical preparation is necessary to make it ready for dyeing or printing. Indigo may contain any proportion up to 75% of indigotin and must be subjected to a long and troublesome grinding process to render it fit for the dye-vat. Most dyers were glad to be relieved of the burden and I have heard it said, that the Germans hastened the abandonment by buying up the machinery.

On his arrival in India, Mr. Davis had no particular difficulty in removing water directly from the precipitated indigo to the extent required to give a paste containing as nearly as might be 20% of indigotin, leaving indigo-brown out of account. He was able to keep this from changing, even under Indian conditions, provided the paste were exposed to air; but on closing up the packages, anærobic organisms became active; apparently, even these could be kept under by an increased dose of alkali. Several casks of the paste were sent to England. When these were opened in my presence, slight gaseous pressure was manifest and a slight fæcal smell, showing that the organisms were not entirely thrown out of action. Analyses seemed to show that the paste was a unit or so below 20% strength. I may here say that the results returned by the different analysts were discrepant and it is clear that the methods of analysis commonly practised need careful revision. The paste was submitted to several competent dyers and declared excellent.

Satisfactory as was this trial on the whole, it was obvious that to send a paste which was mainly water all the way from India, could scarcely be an economic proceeding; soon, however, owing to the war, it became difficult, if not impossible, to procure casks or other suitable packages; later on, even cake indigo could rarely be shipped.

We therefore determined to continue the inquiry here and endeavour to make a paste from cake indigo, so as to gain ex-

perience and to avoid the sacrifice of opportunity. Fortunately, Mr. Reginald Brown was induced to undertake the task; great credit is due to him for the good work he has done and the proof he has furnished, that paste prepared from the natural material is not only equal but superior to synthetic indigotin for most dyeing purposes. It is only within the last three years, however, that the process has been made a commercial reality and success. The superiority is, I believe, due to a specific effect of indigo-brown in the dye-vat.

When the task was undertaken in earnest, the two chief difficulties encountered were the selection of suitable mechanical means of mixing and grinding and the preservation of the paste. Eventually, by grinding successively in machines of two different types, both used previously only in the preparation of pigment colours, even the hardest varieties of cake indigo (requiring at least a fortnight's grinding in the ball-mills formerly used) were converted, in the course of two or three hours, into a paste indistinguishable in fineness from synthetic indigotin paste, satisfying, in this respect, the most exacting demands of the dyer and even of the calico printer. The two pastes underwent reduction with equal ease both in the hydro-sulphite vat and in the zinc-lime vat.

To ensure that the paste shall keep has been a more difficult task. The incidence of bacterial action is very slight below 60° F. but trouble is experienced, at British summer temperatures, unless prevented by a suitable addition to the paste. The usual antiseptics are ruled out, as their presence might interfere with the course of useful processes in the "woad vat" or other fermentation vats (that this interference actually *does* take place has not been definitely established), though in paste to be used in the hydrosulphite or zinc-lime vat there is no objection to the presence of either phenol or formaldehyde.

From the trials made with a large number of substances, at a range of temperatures from 60° to 120° F., it appears that a small addition of paranitraniline (0.05% of the weight of the paste) retards bacterial change almost entirely and is without interference in the dyeing process; natural indigo paste containing this addition can be stored during many months in temperate climates without fear of deterioration. In tropical countries, however, the presence of paranitraniline is insufficient to prevent all decomposition; evidently some highly resistant organisms are not destroyed by it. Experiments are, at present, in progress to adapt to the commercial scale another sterilisation method, which has been proved effective in the laboratory.

Natural indigo paste now has a ready sale in this country, the quantity being limited only by the supplies of cake indigo which the planters are able and willing to furnish at a price enabling the paste to be prepared and sold in competition with synthetic indigotin; this quantity has not been large, because the prices ruling in the Eastern market have been higher. The real market for indigo will probably always be in the East.

With regard to the dyeing properties of indigo paste, it is certainly superior to synthetic indigotin. To quote from a statement I made in *The Times* of April 8th, 1920:—

"Trials of a strictly scientific character have been made with piece goods, on a practical scale, by Messrs. George Garnett and Sons (of Apperley Bridge, near Bradford), a firm of great experience as indigo dyers. Vats were set and worked with equal proportions of natural and artificial paste; two pieces were dyed at a time, equal weights of cloth being taken for each vat. The number of comparisons thus made was 37, using 74 pieces of cloth. In each comparative trial the depth of shade produced was greater in the vat charged with natural paste. Mr. Reginald Brown estimates the superiority in depth in the series of dyeings at from 5 to 20 per cent. or an average of 12.5 per cent. The difference is patent even to my uninstructed eye. A serge properly dyed with indigo should always rank superior to one dyed with indigotin only."

I should add, in fairness, that synthetic indigotin is superior for light shades, especially in printing discharge patterns upon calico, as the whites are left clear and bright.

"The marked superiority of the natural product must be ascribed," I said, "to the presence of constituents other than the blue dyestuff indigotin, the sole constituent of the manufactured article. Indigo, in other words, is a material different from indigotin. The Germans are not to be credited with the production of indigo, but only with having made its chief con-

stituent—a sufficiently notable achievement, however. It is not permissible, in fact, to speak of synthetic indigo; nor is it necessary to speak of indigo as natural indigo."

Indigo dyed cloth has a peculiar bloom, a hue and tone which are distinctive: hence the preference in which it is held by those who are judges.

In concluding this section, I may add that in preliminary experiments, Mr. Davis has found that it is possible to air-dry indigo to an easily pulverulent form in which it requires practically no grinding. I believe this will ultimately prove to be the best form for export and one likely to satisfy all requirements if supplied of standard quality; until then indigo should be sent out as standardised paste.

The Manufacture of Indigo from the Java Plant.

In 1919, I dealt mainly with the agricultural problem, particularly the phosphatic depletion of Indian soils; nothing was said of the process of manufacture. Systematic work has been carried on since 1917, at Pusa, to elucidate this process, by Mr. Davis in collaboration with the Imperial Agricultural Bacteriologist, Mr. C. M. Hutchinson; considerable progress has been made, especially during the past season or two. In spite of much work by previous observers, practically nothing was known of the exact course of the process of extraction.

The dyestuff is not an immediate natural product. Its precursor in the leaf is the simpler substance, *Indoxyl*, C_8H_7ON, which is present in combination with the sugar, glucose, $C_6H_{12}O_6$, as the glucoside, $C_{14}H_{17}O_6N = C_8H_6ON.C_6H_{12}O_6$ *Indican*, which is easily soluble.

To produce indigo, it is necessary that the indican should be extracted from the leaf; that it should then undergo hydrolysis:

$C_{14}H_{17}O_6N + OH_2 = C_8H_7ON + C_6H_{12}O_6$;

and that the indoxyl thus obtained should be converted into indigo by oxidation:

$$2C_8H_7ON + O_2 = C_{16}H_{10}O_2N_2 + 2OH_2.$$

The plant is cut at daylight and carried as quickly as possible in carts to the factory, where it is packed in large cement-lined tanks; when the charging is complete, water is run in; then after several hours' steeping, the extract is run off into beating tanks, where the liquid is brought into contact with air and the indigo precipitated. As much of the liquid as possible having been run off, the sludge is removed to filters and then to presses; finally, the press cakes are dried in the air.

Mr. Davis has discussed his earlier observations on the extraction process at length in Indigo Publication No. 9, published a year ago.

Two main problems are to be solved: first comes the nature of the process by which the leaf is rendered permeable, so that water can enter and the indican pass out into solution; and second, the process by which the hydrolysis is effected. A natural leaf is impervious. At the outset, a more or less vigorous bacterial fermentation is set up in the tank, doubtless at the expense of sugary materials exuded from the cut ends of the plant stalks and bruised leaves. The water used in Bihar is usually hard and alkaline. During the first three or four hours, little, if any, indican is extracted; then, as the solution becomes acid and acidity increases, more and more passes out and is usually hydrolysed forthwith. In Bihar the best results are obtained by stopping the steeping process after about 12 hours; if it be continued beyond the optimum period, destructive changes take place which involve both a loss of indigo and an increase of impurities in the product.

It would not have been a surprise had it been found that organic acids were formed by fermentative action during the earlier period. This is proved not to be the case; the development and increase of acidity is mainly due to carbonic acid. As this acid by itself acts but slowly upon leaves, although it ultimately renders them permeable, it is probable that the change at the leaf surface is due rather to a combination of circumstances leading to the death of the leaf and the onset of internal changes which involve complete degradation of the vital mechanism. Not only is carbonic acid formed but oxygen disappears from the solution; and the leaves are in the dark and immersed in water—all unnatural conditions. Nevertheless, weak as it is, carbonic acid demonstrably plays an extraordinary part in the process, the quality of indigo produced being the worse the more freely the acid is formed.

Previous workers have inclined to the belief that the indican is converted into indoxyl and glucose by the agency of an enzyme present in the leaf. Messrs. Davis and Hutchinson, however, have brought forward a body of evidence which the

former is inclined to interpret as proof that organisms play a preponderating part. Mr. Davis is even of opinion that the enzymic actions within the leaf are rather to be avoided, as they lead to undesirable results. When the extraction process is set going at the beginning of a season, usually the results are poor at first, the product being low in quantity and quality. The following data from records secured in 1916 are typical:—

	Sumatrana Plant.		Java Plant.
	Produce per 100 maunds.		
	Sr.	ch.	Sr.
1st day ..	0	5	7.4
2nd ..	1	2	10.1
3rd ..	7	1	6.0
4th ..	8	0	14.8
5th ..	Java Plant		12.8
6th ..			14.0
7th ..	11	6	16.0
8th ..	9	6	14.0
9th ..	12	2	steadily 14-16

Apparently during the earlier period the useful organisms are accumulating on the walls and cross-beams of the steeping tanks. Mr. Hutchinson has developed a method of cultivating the organisms which occur in the vats on plates of agar containing indican: organisms growing upon these which liberate indoxyl are easily distinguished by the blue colour of their colonies. Using this test, Mr. Davis has found extraordinary differences in the way in which the different organisms affect indican, both as regards the rate at which they determine its hydrolysis and the extent to which they exercise a destructive action.

An interesting opportunity was afforded him in 1919 at a small factory at Panchnoi, in Assam, where the manufacture was undertaken for the first time in Assam by Mr. Leo West. During the first month, in which, following the Bihar practice, steeping lasted 12 hours, the results were most irregular and unsatisfactory; only from 3 to 13 seers per maund were obtained of an indigo of low quality, containing from 31 to 53 per cent. of indigotin. The water used was found to be entirely different from that in Bihar, being very soft. When bacterial cultures were made by Mr. Hutchinson's indican-agar method, the water, as a rule, was proved to be extraordinarily deficient in indican-splitting organisms.

Mr. Davis further found that when the Panchnoi water was added to a sterilised solution of indican, the production of blue indigo set in only after 36-40 hours, whereas, when ordinary Bihar water—well supplied with indican-splitting organisms—was used, a blue deposit of indigo was obtained within 12 hours. In carrying out the 23rd to the 29th extractions, during which period the results were most variable, it was noticed that, whereas on satisfactory days there was a good development of the indican-splitting organisms on the agar plates, this did not happen on the other days. The water was obtained from a small river rising in the hills a few miles away and evidently changed its bacterial character very rapidly as the rainfall in the hills varied. At the 33rd extraction it occurred to Mr. West to double its duration: a very high yield and greatly improved quality of indigo was then obtained and this condition continued regularly over 30 days in succession. In Bihar, if extraction be continued beyond 24 hours, the produce is very poor. The following example of results from a steeping vat will illustrate the rapidity with which deterioration sets in:—

Time of steeping	8 hrs.	11 hrs.	13 hrs.
Percentage of total indigotin of leaf found in extract ..	45.4	83.0	56.6
Purity of crude indigo ..	71.8	66.6	51.8

It will be seen that a loss of nearly two-thirds of the indigotin was incurred by two hours' over-steeping.

Mr. Davis was led by these observations to realise that it would be of great advantage to ascertain the optimum time of steeping under the particular conditions prevailing in each factory and ultimately to devise a simple time test. This involves nothing more than taking a sample every half-hour from the running-off pins or by means of a syphon from the bottom of the vat. Five cubic-centimetres of the sample are measured into a flask and after six to eight drops of strong ammonia diluted with five volumes of water have been added, the liquid is made up to 250 cc. and well shaken; finally it is poured into a 100 cc. Nessler cylinder. The successive samples are ranged in order and the depths of colour observed. So long as the extraction is incomplete, the depth of blue colour steadily increases; directly the blue colour begins to appear fainter, extraction should be stopped.

Using this test in Bihar, it is found that every half-hour counts: marked improvements in quality and constancy of product have been effected wherever the test has been introduced. It constitutes a great advance in the technique of the extraction process. Moreover, other improvements are likely to come in its train, as Mr. Davis has found by its use that, not only does the extract at different heights in the vat vary in strength but that the closeness with which the charge is packed is of consequence, as the proportion of potential indigotin dissolved out depends upon the ratio of water to plant.

To return to the problem of bacterial action, whilst it is clear that organisms play a determining part, it is not so clear what part the leaf enzymes take in the process; judging from the Panchnoi results, they do not seem to be specially active; it is difficult to understand the slowness of the extraction. Unfortunately, these experiments were not carried to the point of ascertaining to what extent the indican had been dissolved out of the leaf at different periods of steeping, nor to what extent it had been hydrolysed; the unsatisfactory results may have been due to a preponderance in the earlier stages of extraction of organisms having a destructive influence upon indoxyl. No proof has been given, moreover, that indican as such escapes to any extent from the leaf: the conclusion Mr. Davis draws from his results is that usually it is hydrolysed to indoxyl practically as fast as it is extracted from the leaf. Maybe the differences observed are all but entirely the outcome of competitive actions by the different organisms: until these are isolated and their individual effect established, it will be difficult to overlook the entire process.

Indoxyl is one of the most sensitive substances known to the chemist. It may exist in solution in two interconvertible forms, in proportions which vary probably with temperature and the effective alkalinity or acidity of the liquid. These may be differently affected by organisms and on oxidation. The results obtained in the beating vat vary as the acidity is varied and the most favourable results are obtained when the solution is neutral or faintly alkaline with ammonia. The main change in indoxyl is more fundamental: apparently derivatives of this compound are present in the liquor which are not convertible into indigo but into indigo-brown, the nature of which is at present unknown; a considerable proportion—often a third—of the indican, however, is carried beyond this stage and for the loss of this we cannot fully account at present.

Carbonic acid may have an influence either by retarding or promoting the action of this or that organism; perhaps its main deleterious action is the solvent action it exercises upon proteinaceous substances present in the leaf, which are subsequently precipitated during the beating process, together with the indigo, thus reducing its purity. The so-called indigo-gluten, soluble in dilute acids, which may form 20 per cent. or more of the crude indigo, is formed in this way.

The process is a remarkable illustration of the manner in which untutored human ingenuity has solved most difficult practical problems in a manner which we cannot well surpass, even with the aid of our great scientific knowledge; at most we can explain their character and so contribute to more regular and successful working. This is the position of the indigo industry.

Whilst the process is one of extraordinary complexity—the mysteries whereof will not be unravelled nor the conflicting elements disentangled without much further labour, combined with the highest technical skill and acumen—the means employed are of striking simplicity: to devise an economic alternative treatment, comparable with it in efficiency, would be very difficult. No effort should be spared, therefore, to master its details, so that the manufacture of indigo may once for all be placed upon a scientific basis: more than a beginning has been made; if the undertaking be interrupted now, a great opportunity will have been sacrificed.

Conditions Affecting Yield of Plant and of Indigo.

Three years ago I drew attention to the evidence Mr. Davis had obtained as to the effect of manurial treatment on the yield and *quality* of the plant: the latter being measured by its richness in *indican*. In the interval he has discussed the subject more fully in Indigo Publication No. 7, published in June, 1920, as well as in a report made in July last.

Systematic trials were begun at Pusa, in 1917, on 12 experimental plots, each one-quarter of an acre in area; on one of these a cover crop of wheat was grown,

together with the Java indigo plant, this latter being in lines two feet apart, the wheat in two rows eight inches apart and eight inches from the indigo plant on either side. The indigo seed was sown in the proportion of four seers, the wheat (Pusa No. 4) of one maund to the acre. The date of sowing was October 24th, 1917. The plot had lain fallow during the previous hot weather and had not been manured. Other plots were sown with indigo seed alone, also in lines two feet apart. The usual plan adopted by planters is to space the rows only six inches apart. Mr. Davis regards this as not only wasteful of seed but as the plant is crowded, when it grows it sheds leaf and has no chance to bush out the percentage of leaf is, therefore, low.

In both years the indigo plant grown together with wheat was very backward in comparison with that on other plots without wheat, up to and some time after the wheat was cut, being only one to two feet high instead of four to seven feet. In 1918, soon after the rain in June, however, the plant grew in a remarkable manner, and when first cut, at the end of July, the yield was greater than on the comparison plots, excepting that on which the indigo plant and wheat had been grown alternately (B10); the second cut was small. In 1919, owing to a very late monsoon, the first cut was small but the second cut made up the deficiency.

The results are given in detail in Tables I. and II. (See pages 417 and 418).

It will be seen that the plant grown together with wheat was extraordinarily rich in indican in comparison with that grown on other plots, even in the 1919 season, when the percentage of potential indigotin was relatively high in all the crops.

From analyses of many hundred samples of Java indigo leaf, cut at various times and grown under different manurial treatments, Mr. Davis has found that, at Pusa, the potential indigotin varies usually between 0.4 and 0.6 per cent.; values as high as 0.7 per cent. are unusual and he has never before found values so high as those obtained in these trials—from 0.8 to nearly 1 per cent. on B.9.

It is well known to planters that, on some estates, certain fields often yield a big crop but little indigo. In the early days of the use of seet as a manure, the indigo plant was frequently grown directly on seeted land but although the crop was greatly increased, it was found that the quality was so much impaired that there was no increase in the amount of cake indigo produced per acre. The importance of this difference was specially noted by me in 1919.

When account is taken of the conditions at Pusa, the results are an indication, apparently, that the main cause influencing the production of indican is a low proportion of nitrogen in the soil. Mr. Davis is of opinion that the conclusion arrived at previously by Bergtheil is correct—that the production of indican is a starvation phenomenon, with the limitation, however, that to obtain also a higher yield of plant the starvation must be restricted to nitrogen.

In point of fact, the yield of indigo in the trials under consideration was inversely proportional to the amount of nitrogen in the soils, as shown in the last column of Table II. In B.9 the nitrogen falls even below the amount present in most indigo soils of Bihar, which usually contain from 0.3 to 0.5%; the percentage in the other plots was considerably higher and nearly three times as great in B.16.

Whereas plot B.9, on which alone the indigo plant was grown together with wheat, containing 0.027 per cent. nitrogen, gave 130 maunds, 37 seers of plant, estimated to yield 47 seers of indigo, the plot richest in nitrogen, B.16, containing 0.076 per cent. (also phosphatically the richest), gave a large crop of 141 maunds 14 seers; yet the yield of indigo from this latter was estimated to be only 25.5 seers.

On contrasting the results of the three years 1918-20, it appears, moreover, that although the climatic conditions varied widely and also the yield of plant per acre, a steady and marked improvement has taken place each year in the quality of the plant—*i.e.* the proportion of potential indigotin—in soils which were either unmanured or treated with phosphate, in some cases the possible yield of indigo per 100 maunds of plant being nearly doubled. The results are summarised in Table III. (See page 419).

The only explanation which can well be given of this steady improvement is that it was due to the gradual elimination of readily available nitrogen. That there was such an elimination seems clear from the fact that on plot B.9 the yield of wheat has steadily and rapidly fallen from year to year, from 11 maunds per acre in 1918 to 2 maunds in 1921. In the season 1921 the results were still better.

TABLE I.

Yields and analyses of Java plant from Punjab experimental plots, **1918.**

Each plot was ¼ acre. Returns are calculated on the acre.

		Moorhan.*						Khoonties.						Total for Season.			
Plot.	Treatment.	Date of cut.	Yield plant per acre		Leaf per cent.	Per cent. indigotin in leaf	Possible yield of 60 per cent. cake indigo per acre	Date of cut	Yield plant per acre.		Leaf per cent.	Per cent. indigotin in leaf	Possible yield of 60 per cent. cake per acre.	Yield of green plant per acre.		Possible yield of 60 per cent. indigo per acre.	Per cent. N in soil 0"-6".
			Mds.	Srs.			Seers.		Mds	Srs			Seers	Mds.	Srs.	Seers.	
B. 9	Wheat and indigo sown together. No manure.	29th July, 1918.	103	28	47.5	0.807	26.5	27th September 1918	10	20	75.0	0.471	2.47	114	8	28.97	0.027
B. 10	Indigo and wheat alternate years. No manure.	8th July, 1918.	116	28	55.0	0.517	22.0	27th September, 1918.	19	4	75.0	0.529	5.05	135	32	27.05	
B. 11	Indigo continuously. No manure.	13th July. 1918.	100	16	51.2	0.473	16.2	27th September, 1918.	17	16	70.0	0.525	4.26	117	32	20.46	0.036
B. 12	August sowing, 1917.	29th July, 1918.	74	24	42.5	0.507	10.7	Not cut—khoonties neglibible, no leaf.						74	24	10.7	
B. 13	Indigo continuously. Super applied October, 1917.	29th July, 1918.	94	31	50.0	0.550	17.4	27th September. 1918.	1	6	75.0	0.399	0.23	95	37	17.63	0.041
B. 14	Super applied after 1st cut, 1918.	30th July, 1918.	99	36	45.0	0.590	17.7	27th September, 1918.	2	6	75.0	0.417	0.45	102	2	18.15	0.041
B. 15	Indigo continuously. No manure.	30th July, 1918.	87	24	47.5	0.566	15.7	28th September, 1918.	4	34	77.5	0.410	1.03	92	18	16.73	
B. 16	Indigo continuously. No manure.	30th July, 1918.	102	36	42.5	0.453	13.2	28th September, 1918.	3	4	73.7	0.459	0.70	106	0	13.9	0.076—

NOTE 1. The analyses of the leaf were made by the isatin method. The values given are the average of two closely concordant duplicate analyses.

" 2. Plot No. 12 was sown in August, 1917, for seed. The seed was collected in March and early April, 1918, and the plant cut down to 6" and left to give a leaf crop, which is, therefore, the second leaf crop. This plot gave no khoonties at all after the cutting in July. It failed to produce fresh leaf.

" 3. The possible yield of 60 per cent. indigo is calculated as follows: for example, plot B. 9—103 mds. 28 srs. = 4,148 srs. Possible yield per acre =

$$\frac{4{,}148 \times 0.475 \times 0.807 \times 100}{100 \times 60}$$ 26.50 seers 60 per cent indigo cake.

TABLE II.

Yields and analyses of Java plant from Punjab area, 1919.

Plot.	Treatment.	MOORHAN. Date cut	MOORHAN. Yield plant per acre	MOORHAN. Leaf per cent	MOORHAN. Per cent. indigotin in leaf	MOORHAN. Possible 60 per cent. indigo cake per acre.	KHOONTIES. Date cut	KHOONTIES. Yield plant per acre.	KHOONTIES. Leaf per cent.	KHOONTIES. Per cent. indigotin in leaf	KHOONTIES. Possible 60 per cent. indigo cake per acre	TOTAL FOR SEASON. Yield of green plant per acre.	TOTAL FOR SEASON. Possible 60 per cent. indigo per acre.
			Mds. Srs.			Seers		Mds. Srs.			Seers.	Mds. Srs.	Seers.
B. 9	Wheat and indigo sown together. No manure.(1)	4th July, 1919	64 7	62.5	0.985	26.35	13th September, 1919	66 30	56.9	0.816	20.65	130 37	47.00
B. 10	Wheat only in 1918-19. No manure.(2)		No indigo grown.					No indigo grown.					
B. 11	Indigo continuously. No manure.(3)	11th June, 1919	46 28	47.8	0.656	9.23	9th August 1919.	51 2	65.0	0.606	13.03	97 30	22.36
B. 12	Seed plant August, sowing, 1918. No manure.(4)		Not kept for green plant										
B. 13	Indigo with super at time of sowing 1st application in 1917.(5)	27th May, 1919.	61 4	46.25	0.689	12.5	6th August, 1919	75 24	61.25	0.616	19.0	136 28	31.5
B. 14	Indigo with super after 1st cut. 1st application, 1917.(5)	27th May, 1919.	61 2	48.75	0.694	13.8	7th August, 1919	71 7	57.5	0.628	17.13	132 9	30.93
B. 15	Indigo continuously. No manure.(6)	12th June, 1919.	54 4	46.9	0.678	11.3	8th August, 1919	51 28	66.5	0.688	15.75	105 32	27.05
B. 16	Indigo continuously. No manure.	4th June, 1919.	62 2	41.9	0.689	11.9	5th August, 1919.	79 12	52.5	0.522	13.58	141 14	25.5

NOTE (1). Yield of wheat on Plot B. 9, March, 1919 = 7 mds 34 srs. 12 ch. per acre. Straw = 15 mds. 29 srs per acre

„ (2). Yield of wheat on Plot B. 10, March, 1919 = 13 mds 24 srs per acre Straw = 25 mds 6 srs. per acre

„ (3). Plant on Plot B. 11 rather uneven. Western half taller and thicker plant. On eastern side much had gone out in patches.

„ (4). Yield of seed. March-April, 1919 = 0 mds. 22 srs. per acre with germination 58 per cent.

„ (5). Phosphate plot cut very early (*before the rains*) as plant was well advanced (tall) and leaf might be lost Even plant. The order of cutting was Plot B. 13 and B. 14 (super) May 27th; B. 16, June 4th; B. 11, June 11th; B. 15, June 12th; B. 9, July 4th.

„ (6). Plant on Plot B. 15 very uneven like B 11—western half much better than the eastern

TABLE III.

			Moorhan.		Khoonties.		Total.		
			% Indigotin in leaf.	Possible indigo Srs. per 100 Mds.	% Indigotin in leaf.	Possible indigo Srs. per 100 Mds.	Yield of Plant per acre	Average indigo per 100 Mds.	Taking 1918 as 100
							Md. Sr.	Srs.	
Unmanured.	B 11	1918	0.473	16.2	0.525	24.5	117.32	20.46	100
		1919	0 656	19 76	0.606	25.52	97.30	22.36	131.7
		1920	0.708	23 12	None taken		135 24	31 35	133.1
	B 15	1918	0.566	17.92	0.410	21.24	92.18	18.10	100
		1919	0 678	20 89	0.688	30.46	105.32	25.57	141.3
		1920	0 763	28 22	None taken		92 20	28.22	155.9
	B 16	1918	0 453	12 83	0.459	22 57	106.0	13 11	100
		1919	0 689	19 18	0.522	17.12	141 14	18 00	137.6
		1920	0.806	24.62	None taken		92 24	24.62	187.8
Super only.	B 13	1918	0 550	18 35	0.399	20.00	95 37	18 38	100
		1919	0 689	20.46	0 616	25 13	136 28	23.05	125.4
		1920	0 796	24 54	None taken		114 9	24 54	133.5
	B 14	1918	0 590	17 72	0.147	20 94	102.2	17 79	100
		1919	0 694	22 60	0.628	24.07	132.9	23 39	131.5
		1920	0.7515	25 04	None taken		140.8	25.04	140.8

From the manurial trials made at Pusa with super and sannai as green manure, it appears that on such soils this treatment not only gives a very high yield of indigo per acre but the quality of the plant is also high, though not quite so high as that of plant grown without manure. When the indigo plant is grown with the aid of indigo seet as manure, there is a big increase in growth of plant but no extra production of indigo. There is a marked difference in behaviour of the plant according as fresh green manure is used or the fermented indigo plant in the form of seet; fresh indigo seet apparently increases the growth of the plant only at a corresponding sacrifice of quality.

The lesson to be derived from the various trials undoubtedly is that it is necessary to ensure three conditions to secure maximum quantity of a high quality plant :—

1. A low proportion of readily available nitrogen in the soil.

2. A good supply of organic matter to furnish the necessary (?) carbohydrate nutriment on which the development of the nodular growths on the roots largely depends.

3. A good supply of soluble phosphate.

The leguminosæ are peculiar plants which seem to lead a double life. They have acquired the habit and power of making slaves of bacterial organisms, which become housed in nodular growths upon their roots—these are the factories in which the assimilation of atmospheric nitrogen is effected. When the plant is grown in sterile soil, nodules are not developed; they appear only when it is grown in a suitably infected soil. Although not indispensable to the plant, the associate bacterial colonies appear greatly to favour its development. Leguminous plants cannot be grown many years in succession on ordinary land; yet at Rothamsted, on a garden plot, which probably was heavily manured in early days, clover grew well over a long period, though gradually the plot became patchy. It is a matter of common observation that, on waste land, a variety of weeds will flourish during the first two or three years, then suddenly these give place to wild-white-clover; in the interval there has been an accumulation of organic matter in the soil. The impression is growing that, to extend the period during which leguminous crops can be grown with success, it will be necessary to maintain a supply of organic elements in the soil and to considerable depths for the deeper-rooted types.

Carbohydrate material seems to be specially valuable. The precise nature of the process by which nitrogen is fixed is not known; it appears less strange than it formerly did, now that ammonia is manufactured on a large scale from nitrogen and hydrogen—but at a high temperature and under great pressure, whilst the plant system works quietly at the always relatively low temperature of the soil, at atmospheric pressure and in the dark. Probably, ammonia is formed initially in the plant by the action of hydrogen generated in a circuit of high potential, as the outcome of the oxidation of carbonaceous material, such as a carbohydrate would supply.

The extent to which the Jekyll and Hyde elements of the strange leguminous partnership function separately appears to depend on the condition of the soil. When the supply of nitrogen is abundant, either as nitrate or as an ammonia compound or in an easily assimilable organic form, the plant is able to function normally, as do other plants; but when these are lacking, the supernumerary organisms are drawn upon and forced into activity. The nutriment they supply is of a special kind, apparently. Probably the nitrogen is laid down initially in the form of a protein, the elements of which are duly translocated into the plant; to account for the increase of indican under the influence of the nodular growths, it is only necessary to suppose that among these elements one yielding indoxyl on reduction (such are known) is relatively abundant.

Mr. Davis is of opinion that, when wheat is grown with the indigo plant and the proportion of indican in the leaf is thereby materially increased, maybe to the extent of 50 per cent., the effect is due to the withdrawal of readily available nitrogen from the soil by the wheat, so that the nodules on the roots of the indigo plant are, as a consequence, forced more into action than would be the case if the plant had a larger store of assimilable nitrogen at its disposal. He is in no doubt as to the importance of a good supply of organic matter, yielding carbohydrate nutriment; also all important, in Bihar especially, is a supply of soluble phosphate: in short, the nutriment conditions must be those which favour the development and activity of the nodules; under such conditions the plant will flourish and be leafy.

It has yet to be ascertained whether indican can be formed, if the indigo plant be grown without nodules; and, on the other hand, whether indican can be produced in the nodules alone. The formation of indican may be more a matter of the production of indoxyl than of the existence of a special mechanism (enzyme) in the plant, able to couple the indoxyl with glucose. It is noteworthy, in this connection, that indigo can be obtained from non-leguminous plants, Woad, for example.

Prior to Mr. Davis' study of the influence of wheat, Mr. Howard had pointed out that on Pusa soil, Pusa 4 wheat and the Java indigo plant could be grown together with advantage; but the general experience of planters who had tried the two together had been that, although a fine crop of wheat may be obtained, the indigo plant largely dies out. In Mr. Davis' opinion, though in some cases this may be due to the soils holding moisture badly, it is mainly because of the poor condition of most planters' soils, the amount of available phosphate being so small that it is used up during the growth of the wheat. He has, therefore, recommended trials on soils treated with superphosphate and either sannai or seet.

Remarkable results similar to those with wheat at Pusa were obtained by Mr. H. A. Inglis, at Bunhar, in the season 1919, by growing on one field the indigo plant with a cover crop of mustard and on another partly with mustard and partly with flax. In the one case, the field had been manured with seet in 1916-17; 15 maunds of wheat and 8 seers of indigo were then produced per bigha. After the indigo plant had been cut, the land was prepared (1918) and superphosphate spread on it at the rate of 2 maunds per bigha before sowing. As to the other field, part had been in fallow and was irrigated with seet water; the remainder had been in fallow and was irrigated with seet water; the remainder had not been manured during four years. The crops were very fine.

Although the total yield of plant per bigha was exceptionally high (over 250 maunds), far higher than is usual in Bihar, the quality of the plant grown with the cover crop was also high, so that the total production of cake indigo per acre amounted to 43 seers 10 chelaks from the one and 41 seers from the other field.

The results are summarised in Table IV.

The indigo industry has always been a migrant industry, fresh lands having been sought for when those used were exhausted.

TABLE IV.

	Indigo and Mustard.						Part Indigo and Linseed. Part Indigo and Mustard.					
	Green plant per bigha		Cake indigo per bigha		Cake indigo per 100 maunds plant		Green plant per bigha		Cake indigo per bigha		Cake indigo per 100 maunds plant	
	Mds.	Srs.	Srs.	Chs.	Srs.	Chs.	Mds.	Srs.	Srs.	Chs	Srs.	Chs.
Moorhan . . .	167	24	21	10	12	14½	171	32	21	5	12	6½
Khoonties . . .	92	20	16	9	17	14¾	81	11	14	10	17	15¾
	260	4	38	3	...		253	3	35	15	...	

Latterly a beginning has been made in Assam, where the plant can be grown with great advantage on newly cleared tea land and between the rows of young tea bushes. By trials made at Panchnoi, Mr. Leo West has shown that it is possible to obtain both a high yield and superlative quality of plant. Unfortunately the disastrous state of the tea trade has prevented development. Mr. Davis regards 200 to 300 maunds per acre for the whole season in Assam as a safe estimate; plant grown specially for mahai and cut at the proper time should contain about one per cent. of potential indigotin in the leaf. The seet from an acre would suffice to manure an acre of land; its use as a manure for tea would reduce the present very heavy outlay on nitrogenous manure; it is also an admirable manure for sugar cane. Possibly, the indigo plant might also be grown together with flax, of which there is now a great shortage.

In Bihar, at the present time, the average produce of Java plant is from 50-70 maunds an acre and the plant is of poor quality, yielding only 40-45 per cent. of leaf containing about 0.6 per cent. of potential indigotin. The cost of manufacturing indigo necessarily depends upon the yield per acre and it will not pay to grow it unless much better returns are obtained than at present. The primary need of Bihar seems to be an improvement in growth of the plant, so that a far higher return per acre may be secured. All other improvements are negligible in comparison with this, if the competition of synthetic indigotin is to be withstood. During the war, the necessary phosphate was unobtainable and supplies are still difficult to obtain at an economic cost; but the issue has to be faced, in view of the high value of indigo seet as a quick acting manure. In Bihar, unseeted land which let at only Rs.20 per acre, after manuring with indigo seet could be let for tobacco-growing at Rs. 100 to 120; the development of tobacco in Bihar, in fact, has been due almost entirely to the use of seet for manure. Now the crop that can be grown in Bihar is so poor that the seet from four to five acres of indigo land will only suffice for one acre. The question is one of expediency: whether it be desirable to raise the level of fertility or to maintain it at a low average.

During his stay Mr. Davis has visited a large number of factories in different districts and analysed more than 600 samples of their soil. The examination of these soils has thrown much light on the manurial requirements of the Tirhoot area. Apparently three distinct classes of soil exist in Bihar, which require very different manurial treatment for the best results. He defines these as follows:

1. The great majority of planters' soils in Tirhoot are deficient in readily soluble or "available" phosphate. In some parts of Champaran this is at present the only soil constituent which is badly deficient and when it is made good by manuring with superphosphate extraordinary increases of crop have been obtained (for example, Byreah, Rajpur, Lalseriah, Turkowlia). Soils which respond to superphosphate alone are found by analysis to be still comparatively well supplied with organic matter (humus)—these parts of Champaran were originally forest land reclaimed for cultivation comparatively recently, within the last 100 years. In these soils the limiting factor is deficiency of soluble phosphate and when this is made

good extraordinary increases of crop are obtained.

2. Most soils in Tirhoot outside Champaran, however, are very deficient in humus as well as phosphate and such soils only respond very partially to superphosphate alone. This class of soil is prevalent in the Mozafferpur district, even more so in Darbhanga and reaches an extreme limit in Monghyr. In some cases, in the last district, the soils are even more deficient in organic matter (humus) than in phosphate and manuring with this alone leads to but little increase. Thus at Munjhoul, some of the soils contain 0.1% or less of humus by the ordinary methods of analysis, whereas a minimum of 0.5% is generally regarded as essential for a fair growth of crops.

In many cases on actual planters' estates extraordinary improvement in the yield of indigo and of other crops has followed the combined treatment with sannai and super. In the case of indigo the yield of plant has been doubled and the produce brought up to 20 to 30 seers per acre or more.

This treatment, no doubt, will also prove beneficial in the case of sugar cane, the cultivation of which has recently been taken up widely and very profitably in North Bihar.

3. There is in North Bihar a third class of soil different from the preceding two classes. This type, instead of containing from 10 to 20 per cent. of lime (CaO) in the form of carbonate, as is the case in most of the soils of Tirhoot, is actually very deficient in lime. These soils are found in a strip of land in the Darbhanga district running through Benipore, part of Mangalgarh (Bagmutti alluvium) and also in the Bhagalpore district. Some of the Bhagalpore soils are deficient in phosphate as well as lime but those of the Darbhanga strip are usually well supplied with available phosphate.

Many of the soils of this third class are very stiff clays and intractable on this account unless ploughed at precisely the right moment. The intractability is probably due to deficiency of lime, which is only present to the extent of 0.1 to 0.5 per cent. and not in the form of carbonate. Such soils would, no doubt, be improved in texture by liming or by incorporating with them the highly calcareous soils of adjacent areas. Some of these soils are also deficient in organic matter.

Very different manurial treatment is required on different estates, according to the nature of the soil: (1) treatment with super alone; (2) treatment either with green manure (sannai) or with green manure combined with superphosphate; (3) treatment with lime alone or with lime combined with green manure or seet. Each planter will have to ascertain what are the requirements of his own particular soils.

In Mr. Davis' opinion, the importance of proper manuring in North Bihar cannot be overestimated it is the keynote to the prosperity of the indigo industry and ultimately of the ryots on small holdings, who depend largely on special crops, such as tobacco and chillies, grown on lands manured with indigo seet. There is no doubt that most estates have been greatly impoverished by lack of proper manurial treatment, especially since the advent of the high yielding Java variety of the indigo plant, which more rapidly strips the soil than other crops. The effect of proper manurial treatment is cumulative. By improving the yield of indigo from the present 50-75 maunds of green plant per acre up to 150-200 maunds per acre (which actual planters' trials have shown to be possible), the output of indigo seet is doubled and so a far more efficient manuring of rabi crops (cereals, tobacco, chillies, etc.), with correspondingly higher yields, becomes possible.

In the competition of indigo with synthetic indigotin, in the future, success will depend as much on the increase in the profit from other crops by manurial treatment as from an increased yield of actual indigo.

Selection of Plant.

Mr. Davis has established the fact that the percentage of indican in the leaf of the indigo plant may vary considerably in accordance with variations in the cultural conditions. There appears to be no evidence that the plant has deteriorated through cultivation in Bihar. The question has been raised, whether varieties which would afford a specially high percentage of indican may not be produced. It is clear that the inquiry into such a problem could not be profitably undertaken except under strictly comparable conditions of soil, which are not easily secured.

It is most unfortunate that the botanist appointed to deal with the problem practically, after but very brief inquiry into the matter on the spot, was led to think that

results of value were not likely to be obtained from selection work aiming at the production of a variety specially rich in indican. He, therefore, did not attempt the task. His reasons carry no conviction to my mind and his conclusions seem to me to be premature. Whatever the chance of success, the inquiry is one that must be undertaken, at an early date, on general grounds, in view of the success achieved with plants of other orders. Whatever the result, most important knowledge of the special behaviour of the leguminous plant will be secured. It is to be hoped that, ere long, a competent botanist may be found who will grasp this great opportunity, realising the importance of the practical issues at stake, in their general bearing on the quality of crops grown under the climatic and soil conditions of India; but he must not be a man who has had all imagination educated out of him.

SPECIAL VALUE OF LEGUMINOUS CROPS.

Finally, I would dwell upon the extraordinary value of an experimental inquiry such as Mr. Davis has initiated into the requirements of a leguminous plant so typical as that yielding indigo. Years ago Sir William Crookes aroused public interest by drawing special attention to the need of nitrogenous fertilisers if the world were to be kept supplied with wheat. Consequently, the advent of the method developed with such success in Germany, of late years, of making ammonia from atmospheric nitrogen and hydrogen liberated from water has been hailed with acclamation; yet it is a method involving much capital outlay and a considerable expenditure of fuel; even where water power is available the capital outlay is great. Nature's method of attracting nitrogen from the atmosphere has yet to be appreciated: at least, in the East, this method alone should be followed; the continued use of costly artificial nitrogenous manures is the outcome of the thoughtlessness and lack of observational and reasoning powers of which we have too long been guilty. We, in this country, make far too little use of leguminous crops—the intervals at which they figure in the rotation are far too long; but, it will be said, this is because they cannot be grown more often. Perhaps a lesson may be learnt from the indigo plant. The majority of our pastures are of the poorest quality as fatting lands and miserably starved of leguminous plants. We have to bear in mind that clover is as meat, whilst the grasses are but as bread. Man cannot prosper, he can barely exist, on bread alone: neither can animals on its equivalent, grass. We know what to do to make our pastures be both bread and meat. On the noted sheep-fatting pastures of Romney Marsh the herbage is a luscious mixture of the youngest grass with clover—*of clover grown with a cover-crop of grass.* It has occurred to no one as yet to question whether the clover grown under such conditions have not a special nutritive value as compared with the plant grown alone. Not only is the clover grown together with grass but both are constantly fed from above, from the animal droppings, with nitrogen, which is a special tonic to the grass, with organic matter and with phosphate, both of which, we may suppose, specially stimulate the growth of the clover.*

The grass-versus-wheat controversy has greatly exercised the public mind of late years, the more because there is an undercurrent of feeling that our grass lands are often inferior and, as it were, meatless lands, yet the farmer has an instinctive love for them, an instinctive belief in their value. Everything is tending now to show the importance of quality as distinct from quantity in food. We, in this country, greatly need to improve the quality of our food, especially of our milk and butter – maybe of our beef and mutton, though as yet we only know that most of it is superior to the meat we get from abroad and that we should do well to raise far more of it at home. Our pigs, we do know, have in large part been imperfectly fed; and pigmeat is certainly much improved in nutritive value by grass feeding. Winter grass is poor feed for milch cows. Of the roots, the

*The sheep play an important intermediary part, which must not be overlooked, not only by keeping the grass young but by transferring the nitrogenous virtue of the clover to the grass and the organic virtue of the grass to the clover; doubtless the two plants also exercise a reciprocal underground influence of a similar kind. The neighbouring pastures on which the ewes are fed with their lambs until these can run alone are totally different in character: the species are the same but the growth is sparse and mature in appearance; there is, doubtless, a great withdrawal of phosphate, which is used in the production of bone by the fast-growing lambs; and fewer sheep are folded on the land. The return to the land is, therefore, less probably in all respects than on the fatting land: it would be interesting to obtain a balance sheet for the two kinds of pasture. The perfection of our old grass lawns is well known: if these could be studied in conjunction with the pastures of Romney Marsh, probably much would be learnt of profit to agriculture. Perhaps some day Oxford botanists will awaken to the fact that "All Flesh is Grass," as Sir Thomas Browne quaintly states in his *Religio Medico*, "not only metaphorically but literally; for all these creatures we behold are but herbs of the field digested into them or more remotely carnified in ourselves."

mangold is seemingly worthless in comparison with the swede, the milk made from it being deficient in nutritive power—and yet we grow and use the former far more than the latter. Of late years seedsmen have vied in producing giant varieties of roots, just as the horticulturists have sought for size in vegetables. Visitors to the Royal Horticultural Society's Shows are familiar with the wonderful display of vegetables by Sir Vicary Gibbs, in particular. But the onion has lost much of its savour, the turnip is all but tasteless, the "not too broad broad bean" has no breadth at all of taste, the tomato is becoming flavourless, etc. Such is the outcome of selection and intensive culture. It is the case of indigo grown on seet, apparently of quantity without quality. We need to pay heed to the lessons Mr. Davis has begun only begun—to draw from his enlightened studies of one poor leguminous plant and begin over again with all our crops.* All is not gold that glitters: we have been thoughtless and so academic in our science that workers are in no way sufficiently alive to the great practical lessons, the great practical issues, before their eyes: too much of the research work we are engaging in is vanity and vexation, in large part trivial and with no practical motive behind it. The differences in value of vegetable products are astounding—the lemon, for example, is a most active antiscorbutic, whilst its near relation, the lime, is worthless. These matters are of the greatest consequence to us all, now that we are beginning to be assured that our growth, our health, our susceptibility to disease are dependent on certain minor and, indeed, minute constituents of our food—that food is primarily of value by reason of its quality rather than of its quantity; and proportion counts. We need many things but we must have them in due proportion—so must the plant.

It were time that we made more use of our knowledge. Man lives not by phosphate alone, nor does the plant; and yet phosphorous is the nuclear element of all living matter and our primary need; sooner or later the nations must fight over its possession. That India is in sore need of phosphates is clear; yet religion and commerce combine to withdraw it from use. That bones should be so largely exported from the country as they are is striking evidence of the alarming ignorance that prevails on all matters of this kind. In a country that can easily start a new religion, a new religion should be founded: one based upon and requiring the reverence of bones and their proper sacrifice in due season to the soil. Our own position is almost equally bad. To make our meatless grass into good sandwich material we need, in the first place, to anoint it liberally with phosphate,* then clover will begin to flourish. Basic slag, we know, is a good material for the purpose and yet we are now spoiling this for agricultural use by an altered treatment in the steel furnace; all the other sources of phosphates are foreign. The problem is of infinite importance. The phosphatic stone Mr. Davis has set rolling in India may roll down even upon ourselves—is already upon us, in fact.

However little moss it may gather, it should force us to think and perhaps to realise the moral burden upon us to make more provident use of the fertilising materials at our door, of which there is so small and limited a store at man's disposal.

My object has been to make clear the immensity and importance of the problems before us in agriculture, especially in connection with leguminous crops. In view of their magnitude, it is the most serious reflection possible upon our intelligence that an industry peculiar to the East and particularly to India, undoubtedly in principle the root industry of its agriculture, of a lineage than which none is more ancient, should have no proper recognition and support. Mr. Montagu, in his recent speech to the House of Commons, spoke of the development of the industrial and agricultural resources of India as the one cure for the present situation. The special correspondent of *The Times*, writing from Bombay a few days later (March 14th), discussing the impressions of a four months' stay, drew urgent attention to India's industrial needs. Agriculture is the chief industry of the country, yet it is to be deprived of scientific aid when it is in sorest need of help.

* The only edible vegetable oil which is reputed to carry the fat-soluble advitant is *Arachis* or ground nut oil, the produce of a leguminous plant much grown in the Madras area. In view of Mr. Davis's observations the effect of varied cultural conditions upon the proportion of the advitant is worthy of study: may be this is connected with the nodular growths in the roots and conditions which favour their development would favour its production. The value of an edible oil, easily produced in large quantity, would be great.

*The extraordinary effect phosphate produces is well brought out in two photographs in the fourth edition of Dr. Russell's "Soil Conditions and Plant Growth" in the new series of Rothamsted Monographs.

Opportunities lost are not regained. To interrupt the investigation at its present stage is an act nothing short of madness. Mr. Davis has proved himself to be an exceptionally capable inquirer. That he would spare no effort and do honest and fruitful work I knew; but that he would show such unusual breadth of outlook and constructive ability I did not anticipate. My recompense, even at this melancholy moment, is the knowledge that I have been so justified of my choice.

DISCUSSION

The Chairman (Sir Thomas H. Holland) said he doubted whether the author would have read the very interesting paper they had just heard were it not for the decision which had recently been taken to stop the research work carried on for the last six years by Mr. Davis, at Pusa. It was a bad budget which did no one any good, and the decision to stop the research work had apparently encouraged the author to gather together his ideas on the very interesting subject with which the paper dealt. The Government of India were faced this year with a deficit which exceeded that of the previous year, although last year's deficit had constituted a record in the financial history of British India In such a time of financial stringency, therefore, one should not, without convincing reasons, urge on the Indian Government the duty of financing the research operations in connection with indigo in which Mr. Davis had been engaged. It could not be said, however, that the author made his demand hastily or without substantial justification. Personally, knowing something of the objects to which public revenue in India was being devoted, he was not prepared to dispute the author's contention; he believed there were even good financial reasons for continuing the research work, at any rate for some years to come. To stop the work at its present stage, when the foundation facts had been established and results of direct commercial value were beginning to be available, would mean the waste of money already well spent. That money, moreover, was not all obtained from the general public revenues; a great part of it could be obtained from a special export cess, which was readily borne by the trade and which was authorised by an Act passed in 1918 for the specific purpose of assisting scientific research work in connection with the cultivation and manufacture of indigo. It was possible that the sum so raised was not sufficient to cover the whole cost of the research work, at any rate during the last two years, when the production and export of indigo had fallen off to a certain extent, but that could easily be remedied by obtaining powers, either prospective or retrospective, to recoup the relatively small sum temporarily lost by drawing on the income which increased exports in the near future would almost certainly yield.

He had been told that the area under indigo had recently been increased, partly as a result of Mr. Davis's experiments, and that next season the crop would greatly exceed that produced last year. It was not a case, therefore, of "spoiling the ship for a ha'porth of tar," because the Government was not asked to give the ha'penny, but only to lend it. If the requisite loan promised only distant and doubtful returns, there might be some reason for adding it to the other petty savings by which the Government hoped to tide over the present period of financial stress; but, in the opinion of those best able to judge, results of financial value, direct as well as indirect, would almost certainly accrue in the near future, if the work were not stopped at the present critical stage.

The author had summed up and confirmed, with the force of recognised authority and with a due sense of relativity, the evidence which the Industrial Commission obtained in 1916-17, from representatives of the various contributory interests—the agricultural chemists, the sugar and indigo planters, commercial men and even from intelligent consumers. He did not propose to detail the conclusions at which that Commission had arrived, because they had been extended and to some extent superseded, by the work the author had described that evening. The author had mentioned many important points which had been established as a result of the research work carried out. In the first place, it had been found that, acting as a soil fertiliser, indigo increased the yield of other crops with which it was grown in association or rotation. Amongst those crops were wheat and sugar. To take the case of sugar, the cultivation of indigo would probably help India to save a large proportion of the enormous sums of money now sent out of the country to pay for imported sugar. For a tropical country to import sugar from a temperate zone four thousand miles away, seemed as surprising as it would be for a Newcastle housewife to send to America for her domestic coal. The author had also referred to the fact that the increased consumption of food grains which was now being indulged in by some millions of Indian workers—the first direct result of the increase of wages following the war—had seriously reduced, if not actually obliterated altogether, the exportable surplus of wheat. The retention of those food grains in the country had meant that India's purchasing power had correspondingly depreciated. Any research work, therefore, which increased the fertility of the soil and accordingly reduced the competition for land between the forests and the agricultural crops (which was now beginning to be severe) added to the wealth of the country in the only way in which that could be done without introducing the accessory

evils which seemed to be the inevitable accompaniments of factory industries. The production for export of an expensive article such as indigo, instead of relatively cheap exports like wheat and rice, must ease the exchange difficulties correspondingly. The adverse balance of trade from which India had suffered since 1920, had added very seriously to the difficulty of paying her so-called Agency charges in sterling. The growing of more expensive crops meant that the land was used more economically, and would be, to that extent, of direct financial advantage to India; for that reason he thought one would be justified in urging the Government of India to reconsider its attitude in the matter. An assured output of natural indigo, moreover, was necessary for the full success of the indigenous textile industry, in which—including the mills and the hand loom weavers and spinners—something like three and a half million workers were engaged. All those workers were Indians, and were dependent on the industry for their livelihood The textile industry was a flourishing one, from which the Government obtained a substantial revenue by direct taxation as well as returns in various indirect ways. An adequate production of natural indigo formed, as it were, an insurance against the monopoly dangers which might arise if the synthetic product completely replaced it; in other words, the cultivation of natural indigo as an industry was important, as a safeguard for the preservation of one of the largest Indian industries. The author regarded the suppression of the research work as involving a danger not confined to India alone. However, personally, he thought it was unnecessary at the moment to consider the Imperial question, because the danger was to India itself. It was not potential, but real; not problematic, but inevitable; not distant, but immediate. No synthetic indigotin was made in India, and no synthetic substitute for indigo would be made in India in the near future. By starving to death her natural indigo industry, the country was placing herself at the mercy of the foreign manufacturer. The Indian political leaders said they feared the English manufacturer as much as, if not more than, the German or American manufacturer; they had the Lancashire bogey always in mind. It was just possible that when India began to employ her new weapon of fiscal independence, she would find the English, American, Continental and Japanese synthetic chemists acting in most embarrassing, if accidental, union. He had been told that one reason why the indigo industry had been selected as a victim for economy lay in the recent change in the constitutional structure of the Indian Government machinery. It was asserted that the first direct results of the researches would benefit an industry largely controlled by British planters and commercial houses, and that, therefore, the Indian members of the central Legislative Assembly, who now, for the first time, controlled the Government of India's budget, would regard with suspicion and almost certainly reject proposals for expenditure on work which was likely to benefit English commercial interests. If the Government of India were unable to state convincingly their reasons for incurring the small expenditure involved, which was probably but a temporary advance, it was just possible that the Legislative Assembly might commit itself to a decision as unwise as some of those which marked, or even marred, the proceedings of the maternal institution at Westminster. From what he knew, however, of the good sense of the Indian Legislative Assembly, and of the way in which it reacted to full and free information, he would be inclined to predict an entirely opposite result. In any case, the responsibility for that result should be placed on the body that had control of the purse. It was not fair to blame the Legislative Assembly for adopting a short-sighted policy when the facts had not been put before them, for although they could cut down they could not legally add to the budget proposals prepared by the Government of India itself What were the facts that might be put before the Assembly in justification of an expenditure of the kind in question? The expenditure involved seemed to him almost negligible compared with that required for, say, a new University for the small city of Delhi, for which the Government had just placed a Bill before the central Legislature. He thought, moreover, that the expenditure of money on indigo research work at Pusa was quite as justifiable as similar expenditure on the cultivation of peaches in Baluchistan.

To what extent was it true that the research work at Pusa would benefit English interests? The cultivation of indigo by Indians was on a distinctly larger scale than that on plantations controlled by Europeans If Indians did not turn the results of the research work to practical account, it would be the fault of their own Ministers, because under the new constitution agriculture was a transferred subject. The dye, too, was largely used by Indians in all parts of the country, and any evil results which might follow its replacement by the synthetic product would affect the textile mills, which were largely financed and controlled by Indians. It was natural to expect that the people's representatives in the Assembly would like to see Indians taking a larger share in the industries and prosperity of the country, but they were not foolish enough to destroy an industry which benefited thousands of Indian cultivators and formed an insurance for the large textile industry merely because a few score English planters grew indigo as well as sugar. Nor were they foolish enough to kill an industry which gave the country a valuable export

without involving the loss of those food stuffs which formed two-thirds of the poor man's budget in India. If the Legislative Assembly had definitely refused to guarantee for a short period only the cess collected—they were only asked to guarantee it—he thought the full facts could not have been placed before the members. The cess was not levied on indigo used in the country itself, but was paid by the foreign consumer in the form of export duty. If his friend Mr. Sarma, the member of the Government of India in charge of Agriculture, had not supported the claim made for indigo research work, he could only suppose the scientific members of the agricultural service must have stated their case very imperfectly to him, because he was too wise to neglect an opportunity of turning science to account in agriculture and too broad-minded to be misled by the false assumption that the results would be for the benefit of Europeans. On the facts it appeared that there had been a misunderstanding of a kind that proper representation should remove, and it would be for the benefit of India if the discussion at the meeting that evening helped the Government to re-open the question afresh. It had been suggested to him that the planters themselves, with the help of the great commercial houses behind them, might properly support the research station without any help from or intervention by the Government; but personally, he would not care to go before the Planters' Association or Bengal Chamber of Commerce with a proposal of that sort. The commercial community had already consented to an export duty in order to finance the research operations. The money so obtained, although paid ultimately by the consumer, was so much deducted from the profits of the producer and exporter, and to that extent they were handicapped in competition both with the synthetic product and indigo produced from other sources. No part of the cess was paid by the army of small dyers in India, who were mainly supplied by the small indigo growers of Madras, the United Provinces, and the Punjab. The European planter was able to take some advantage already of the research work which had been done. To some extent he was able to carry on experiments, though more expensively and less efficiently, in his own factory. The small Indian producer, however, could do neither of those things. His methods would remain just the same until the research work was relatively complete and the improvements could be demonstrated to him by the agricultural officials in ways more likely to impress him than monographs and pamphlets. The final results would affect him considerably, whereas he would get no advantage at all from work that had not reached a stage which justified demonstration by the ordinary subordinate agricultural officials. The planters who might continue the work in their own factories, being sane business men, were not likely to publish their results or demonstrate their methods. It seemed to him, therefore, that the curtailment of the Pusa researches was likely to affect the poor Indian cultivator very seriously indeed. To ask the Planters' Association or the Bengal Chamber of Commerce to finance the work at Pusa for the benefit of the general public, was too much to demand of business men. They had already gone as far as wisdom justified in paying the cess on exports. In addition to that, the planters had suffered a great deal in Bihar from the mischievous activity of agitators, who stirred up racial animosity. English commercial men had not been encouraged recently to extend public spirit in a direction likely to be utilised by unscrupulous politicians. He was not referring to the Indian leader who represented his community in the Legislative Council, whose objects were perfectly sane and understandable and whose proposed reforms received the support of all enlightened Europeans, but to the man who, following Gandhi, objected to all improvements and progress because, and merely because, they were English in origin. It needed a very small number of such men, working on a credulous and ignorant population, to injure their own country as much as they injured the indigo planter The indigo planter was perfectly well aware that if he, through altruistic motives, encouraged work of the kind in question, he might or might not receive the benefit from it himself. He did not make those remarks with the object of impressing Indian agitators, but to explain the attitude adopted by the English commercial men—planters as well as business men—in Calcutta. They had, in his opinion, gone as far as business men were justified in going in agreeing to the export duty on indigo.

He was tempted to refer to the scientific aspects of the question which the author had dealt with, and especially the employment of phosphates, but many distinguished authorities on the various branches of the subject were present and would probably like to join in the discussion, so that time did not permit.

DR. J. AUGUSTUS VOELCKER said that one thing had been made quite clear, namely, that scientific enquiry would play a great rôle in the future development of the indigo industry. The enquiries which had already been made appeared likely, in the near future, to lead to useful results. When he was in India, about 1890, the indigo planter was largely at the mercy of the people who posed as scientists rather than actually being such, and one could not be surprised that very much progress was not made at that time. He thought the first serious effort at an independent scientific enquiry was made by Mr. Christopher Rawson, who read a paper on the subject before the Indian Section of the Society in 1900. Since the outbreak of the war Mr. Rawson had

interested himself more in the synthetic product, and it was not until the author, with Mr. Davis, whom he introduced to the work, came upon the scene, that the problem was really thoroughly tackled in a way which gave hope of success in the future. From what those present had heard that evening, and from what they knew, he was sure they would very much deplore the giving up of research work in connection with indigo. The question at the present time, as in 1890, was the two-fold one of an increased production of crop and a greater out-turn of dye. The work done at Pusa did seem to hold out the hope of increasing the production through the use of phosphates. On the matter of out-turn of dye he was not qualified to speak, but he would much like to know to what extent manufacturers had taken up the various improvements that had been suggested. The enquiries which had been conducted had emphasised the need for the study of the growth of leguminous crops. As the author suggested, attention had been directed in the past more towards the growth of cereals as affected by leguminous crops, and the growth of leguminous crops themselves had been insufficiently studied. One of the first things that impressed him on going to India was that the Indian, although he did not call himself a scientist, knew a good deal more about the scientific side of agriculture than he was given credit for, as was shown by the fact that he practised, without knowing it, a regular rotation of crops which the best scientist could not improve on. It had long been thought that the leguminous crop collected nitrogen for the benefit of the corn crop, and that the ground was thereby enriched The author had described the reverse of that process in his paper, and had shown that the growing of a corn crop-wheat, might benefit by taking the extra nitrogen out of the soil, so making the soil poorer and enabling the indigo to grow better.

MR. G. WATSON mentioned that since Mr. Davis's appointment the annual sum expended on indigo research work had not exceeded £4,000, half of which, up to the present year, had been paid by the cess.

MR. R. BRIDGETT said a good deal had been heard about the production of indigo and the advisability of producing it, but as a dealer and a merchant he would like to say something about the consumption side of the question. It was important to encourage people to wear clothing dyed with natural indigo: if there was a demand for any article production would follow as a natural consequence. There could be no doubt that most dyers preferred synthetic to natural indigo because it was easier to use; but if the public demanded that their clothes should be dyed with natural indigo the dyers would have to use it. The largest users of blue cloth were the Government, for uniforms and police clothes. A long time ago the Government had a clause in their contracts insisting that natural indigo should be used, and the decline of the natural indigo industry dated from the time that clause was removed. A memorial, signed by many influential persons, asking for the reinstatement of that clause was presented to the Government in 1914, but without result. The railway companies were also large users of blue cloth, and if they could be made to see the advantage of having their uniforms and upholstery dyed with really good dye it would be one of the best means of helping the natural indigo industry. The demand to-day was all for cheap goods, including cheap clothes dyed with inferior dyes; if people would only buy good things, and good dyes that would last, it would be a great advantage to both themselves and the indigo trade.

SIR LANCELOT HARE, K.C.S.I., C.I.E., in proposing a vote of thanks to the author for his valuable paper, said he was very interested in the indigo question, because for five years he had been in charge of one of the principal indigo growing districts. He was sure those who opposed any assistance being given to the industry on the ground that a few English planters might benefit could not be aware of the enormous advantage the agricultural industry derived from the presence of a large number of intelligent planters, who carried on experiments and showed how better growth could be produced. The manner in which they looked after the ryots was also extremely beneficial. He would be very sorry to think that the indigo industry was going to be broken up and that the planters would have to go away from the district, as they had to go from Eastern Bengal. He had been interested to learn that experiments in the growth of indigo were being conducted in Assam. He was stationed in Assam for some time, and was sure that if the indigo industry could be developed there great progress would be made by the assistance which the large number of planters who were scattered throughout the province would give. He was also very much interested in the remarks the author made as to the possibility of developing, some day, a pure culture of the bacteria which produced the desired result, and of sterilising the wash, whatever it was. Such sterilisation had done a great deal of good in the production of beer and wines. He knew a little about that, because for some time he was in charge of the Excise Department in Bengal. Experiments which they made—principally with a view to taxation—showed the most extraordinary differences in the development of alcohol from the different washes, and it was found that that was due to the fact that the washes were not sterilised.

MR. T. D. CHADWICK, C.I.E. (Indian Trade Commissioner), in seconding the motion, said the author was one of the leading agricultural chemists, and his enthusiasm, vigour and breadth of view had been an inspiration to the chemists in India. He had given great praise to Mr. Davis, but personally he was sure that Mr. Davis would be the first to acknowledge that the fact that the author was watching his efforts had been a great stimulus to him Mr. Chadwick on behalf of the Council and the Indian Committee, welcomed their Chairman that evening. Sir Thomas Holland had come from India with a very fine record of work done to help the industrial development of India, and it was very right and appropriate that he should take the chair at a meeting called to consider one of the oldest of Indian industries, which was both industry and agriculture.

The vote of thanks was carried unanimously.

PROFESSOR ARMSTRONG, in reply, thanked the Chairman for the very substantial and important contribution he had made to the subject, which would prove very valuable. He trusted something would be done but it would have to be done immediately, because only a few days ago he heard from Mr. Davis that not only was he leaving but the staff of Indian workers he had carefully trained was also under notice; he himself expected to leave about the middle of April. Reference had been made to the possibility of developing the use of pure cultures and sterilisation. That was by no means a distant hope, not only as the culture might be produced but because a very successful method whereby water could easily be sterilised on a large scale had recently been developed; on a small scale that process had already been found of considerable assistance in connection with indigo. A question had been asked as to the extent to which the improvements resulting from the research work had been applied in manufacture. The experiments had been carried out not on a small scale but at different factories and in some cases a very substantial benefit had already accrued. Mr. Davis had not dealt with the matter from a laboratory point of view but had gone to the planters and the fields; his work had been practical from the beginning.

The meeting then terminated

NEW GERMAN METALLURGIC PROCESS.

The attention of metallurgists has been attracted to a process recently invented in Germany which, it is declared, furnishes a simple, rapid, and effective method of separating alloys into their metal components and extracting metals from mineral ores. This process is said to present many advantages over the method hitherto employed of melting alloys and separating metal components.

According to this process, writes the representative in Berlin of the United States Department of Commerce, the metals treated with the catalytic agent go into solution in a very short time, the treatment of big blocks of metal being effected in less than 30 minutes. Out of the solution thus obtained the various metals are dissected by the employment of simple methods of chemical reaction, which permit the retaining of the metals one by one. The product first obtained is in the form of a muddy sediment which, after being dried, yields a metal powder ready to be used or melted in crucibles, or to be treated by electrolytic process. Metals and concentrated ores can be treated in the same way, although they require one or two more operations than pure metal alloys. It is stated that the catalysator employed can be bought in the open market in any quantity required, the greater part of it being recuperated in the process and used again.

It is claimed that this process offers many advantages over the present methods employed. The general expenses involved are declared to be relatively small. The installation and appliances are quite simple. The elimination of the melting process does away with the outlay for coal for that purpose It is further declared that the workmen necessary require no special experience. The process is susceptible of being employed on a large scale, quite a number of charges being treated at a time The apparatus can furthermore be constructed to work continuously, being served in series by the same gang of workmen at the same time, thus reducing to a minimum the manual labour required

It is asserted that the process is effective with any number of metal components, every metal being recuperated separately, and in the case of concentrated mineral ore every component metal part, be it silver, antimony, tin, lead, nickel, or copper, being retained one by one in the purest form

The inventor of this process is an engineer of many years' experience. It further appears that he has developed a new process for the electrolytic treatment of metals, which is said to be much simpler than the methods hitherto employed. This new method enables one to procure copper wire directly out of the electrolytic bath, thereby eliminating the melting down of the electro blocks obtained under the old process, the rolling of the blocks into plate, and drawing into wire. It is claimed that this process accomplishes an immense saving in coal, wages, and time, and while some necessary improvements in the appliances remain to be perfected, the principal problem, it is said, has been solved in a most satisfactory way.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, MAY 1..Royal Institution, Albemarle Street, W., 5 p.m. Annual Meeting.
Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. (1) Annual Meeting. (2) Messrs. J. J. Fox and A. J. H. Gauge, "The Determination of Tar Acids and Tar Bases in Drainage and Mud." (3) Mr. A. J. H. Gauge, "The Disposal and Purification of Flax Retting Effluents."
Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Sir Henry Rew, "Local and Imperial Taxation as affecting Agriculture."
Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. J. O. F. Murray, "The Resurrection of our Lord Jesus Christ."
Electrical Engineers, Institution of (Western Centre), at the South Wales Institute of Engineers, Cardiff, 6.30 p.m.
University of London, King's College, Strand, W.C., 5.30 p.m. Dr. J. Hjort, "Biological Aspects of Oceanography." (Lecture II.)
At Bedford College for Women, York Gate, Regent's Park, N.W., 5.15 p.m. Prof. E. Claparede, "L'Intelligence et la Volonté." (Lecture II.)

TUESDAY, MAY 2..African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. C. F. Reg, "Abyssinia of To-Day."
Alpine Club, 23, Savile Row, W., 8.30 p.m.
University of London, King's College, Strand, W.C., 5.30 p.m. Dr J. Hjort, "Biological Aspects of Oceanography." (Lecture III.) At Bedford College for Women, York Gate, Regent's Park, N.W., 5.15 p.m. Prof. E. Claparede, "L'Intelligence et la Volonté." (Lecture III.)
Royal Institution, Albemarle Street, W., 3 p.m. Prof. Sir Arthur Keith, "Racial Problems of Africa." (Lecture II.)
Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. (James Forrest Lecture). Sir John A. F. Aspinall, "Some Post War Problems of Transport."

WEDNESDAY, MAY 3..People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m.
Public Analysts, Society of, Burlington House, Piccadilly, W., 8 p.m. (1) Messrs J. Lizius and N. Evers, "Studies in the Titration of Acids and Bases." (2) Mr. A. Mitchell, "Graphites and other Pencil Pigments." (3) Dr. J. C. Drummond, "The Sulphuric Acid Reaction for Liver Oils and its Significance." (4) Messrs. W. Singleton and H. Williams, "Inadequacy of 'A.R.' Test for Alkalies in Calcium Carbonate."
British Academy, at the Royal Society, Burlington House, Piccadilly, W., 5 p.m. Sir Israel Gollancz, "The Merchant of Venice." (Annual Shakespeare Lecture.)
Archæological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Mr. A. H. Thompson, "The Church and College of Cotterstock, Northants."
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 3 p.m. Annual Meeting.
Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Prof. Sir Ernest Rutherford, "The Relation of the Elements."
University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Prof. C. Winkler, "The Human Neo-Cerebellum." At Bedford College for Women, York Gate, Regent's Park, N.W., 5.15 p.m. Prof. F. Galdensperger, "Une Destinée Littéraire Anglo-Française · Alfred de Vigny." (Lecture I.)
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section.)

THURSDAY, MAY 4..Chadwick Public Lecture, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Sir Lawrence Weaver, "Rural Re-Settlement and its Relation to Public Health." (Lecture I.)
Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.
Mechanical Engineers, Institution of (North-Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m.
Linnean Society, Burlington House, Piccadilly, W., 5 p.m. Prof. Lloyd Williams, "The Life-history of Laminaria and Chorda."
Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W., 10.30 p.m. Annual Meeting. (1) Presidential Address. (2) Mr. F. Clements, "British Siemens Furnace Practice." (3) Mr. D. E. Roberts, "Notes on Blast Furnace Filling." 2.30 p.m.: (1) Mr. H. C. H. Carpenter and Miss C. F. Elam, "Effect of Oxidising Gases at Low Pressures on Heated Iron." (2) Mr. C. R. Austin, "Hydrogen Decarburisation of Carbon Steels, with notes on related phenomena." (3) Mr. E. W. Ehn, "Influence of Dissolved Oxides on Carburising and Hardening Qualities of Steel."
University of London, at King's College for Women, Campden Hill Road, W., 4.30 p.m. Prof. V. H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture II.)
Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. B. Barton, "A Syntonic Hypothesis of Colour Vision."
Auctioneers and Estate Agents' Institute, 34, Russell Square, W.C., 3 p.m. Annual Meeting.
Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Messrs. I. E. Balaban and F. L. Pyman, "Bromo-derivatives of Glyoxaline." (2) Mr. E. P. Perman, "The Properties of Ammonium Nitrate. Part IV. The reciprocal salt - pair $NH_4NO_3 + NaCl \rightleftharpoons NH_4Cl + NaNO_3$. (3) Messrs. E. C. C. Baly and H. M. Duncan, "The reactivity of Ammonia." (4) Messrs. E. C. C. Baly, I. M. Heilbron, and D. P. Hudson, "Photocatalysis. Part II. The photosynthesis of nitrogen compounds from nitrates and carbon dioxde."

FRIDAY, MAY 5..Royal Institution, Albermarle Street, W., 9 p.m. Dr. M. Grabham, "Biological Studies in Madeira."
Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. E. N. Ching, "Pressure Casting."
University of London, King's College, Strand, W.C., 5.30 p.m. Dr. J. Hjort, "Biological Aspects of Oceanography." (Lecture IV.) At Bedford College for Women, York Gate, Regents Park, N.W., 5.15 p.m. Prof. F. Baldensperger, "Une Destinée Littéraire Anglo-Francaise: Alfred de Vigny." (Lecture II.)
Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W., 10.30 a.m. Annual Meeting continued. (1) Mr. D. Selby-Bigge, "Recent Developments in Power Production." (2) Messrs. A. Westgreen and G. Phragmen, "X-ray Studies on the Crystal Structure of Steel." (3) Mr. N. T. Belaiew, "The Inner Structure of the Pearlite Grain." 2.30 p.m. (1) Mr. J. H. Whiteley, "Formation of Globular Pearlite." (2) Mr. A. F. Hallimond, "On delayed Crystallisation in the Carbon Steels: the Formation of Pearlite, Troostite and Martensite." (3) Mr. K. Honda, "On the Constitutional Diagram of the Iron-Carbon System, based on recent investigations." (4) Messrs. K. Honda and T. Kikuta, "On the Stepped A1 Transformation in Carbon Steel during rapid cooling."
Chemical Industry, Society of (Manchester Section), at the Textile Institute, 16, St. Mary's Parsonage, Manchester, 7 p.m. Mr. N. A. Bellwood, "Progress of Oil Extraction and Kindred Trades."

SATURDAY, MAY 6..Royal Institution, Albemarle Street W., 3 p.m. Prof. D. H. MacGregor, "Industrial Relationships." (Lecture II.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday morning of the week preceding the Meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 409,

Journal of the Royal Society of Arts.

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FRIDAY, MAY 5, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FUND FOR PURCHASING THE SOCIETY'S HOUSE

FOURTH LIST.*

	£	s.	d.
Amount previously acknowledged	41,810	7	0
Thomas McMorran, Esq. ..	100	0	0
The Grocers' Company ..	50	0	0
Sir Henry Ledgard	20	0	0
Miss Julia Lindley (in addition to previous subscription of £50)	10	0	0
Jehangir K. B. Mehta, Esq. ..	10	0	0
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William Nunn, Esq.	5	0	0
Hon. Mr. Justice T. W. Richardson	5	0	0
J. W. Richardson, Esq. ..	5	0	0
Richard William May, Esq...	3	3	0
Richard Henry Taylor, Esq., O.B.E.	3	3	0
James Erskine Aird, Esq. ..	3	0	0
William Anderson, Esq., J.P.	2	2	0
Fred Henry Andrews, Esq. ..	2	2	0
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John Thomas Lewis, Esq. ..	2	2	0
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Matthew Dale Neil, Esq. ..	2	2	0
Miss Jessie Smith Trumpour, M.D.	2	0	0
John Buchanan, Esq., A.I.M.Mech.E...	1	1	0
Carlos F. de Landero, Esq. ..	1	1	0
David Thomas Livesey, Esq...	1	1	0
Percy Edward Marshall, Esq.	1	1	0
F. G. Royal-Dawson, Esq., M.Inst.C.E.	1	1	0
Pandit Sri Krishen Gurtu, M.A., M.Inst.C.E.	1	0	0
Sahebzada Abdussamad Khan, C.I.E.	1	0	0
Cyril Price, Esq.	0	10	6
Interest on deposit account ..	153	10	10
	£42,256	16	4

The above list includes all subscriptions received up to April 30th. Further lists will be published in the *Journal* from time to time.

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will enable them to renovate and decorate the House and make it more attractive and convenient.

*The three former lists were published in the *Journals* of December 2nd, 1921, and January 13th and February 24th, 1922.

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 10th, at 8 p.m. (Ordinary Meeting). MAJOR PERCY A. MAHON, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work." SIR MARTIN CONWAY, F.S.A., M.P., in the Chair.

Further particulars of the Society's meetings will be found at the end of this number.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, APRIL 25th, 1922; SIR JOHN F. C. SNELL, Chairman of the Electricity Commissioners, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Ahuja, M. R., B.Sc, Amritsar, India.
Bhan, S. N., B.Sc., Madura District, India.
Curtis, S. Rumson, Newton Abbot.
Duxbury, George C., Margate.
Giffard, Edgar Osbert, Hove
Gillespy, George Thomas, A.M.I.Mech.E., M.I.Mar.E., London.
Horne, Robert Alexander, M.I.N.A., Rangoon.
Lance, Ernest Solomon, A.M.I.E.E., Llandudno.
Maartens, William Jacobus, Bloemfontein, South Africa.
Mehta, Jehangir Merwanji, Bombay, India.
Mehta, Manubhai Nandshankar, C.S.I., M.A., LL.B., Baroda, India.
Moss, Charles Samuel, Moose Jaw Sask., Canada.
Patel, Hormusji Dossabhoy, Bombay, India.
Rowlandson, Major Charles William St. John, London.
Saxona, M. Amba Prasad, Rajputana, India.
Shank, John Verrall, Coorg, S. India.
Sharman, Dr. B.D., B.A., M.B., M.R.A.S, Calcutta, India.
Shaw, Pran Krishna, B.A., Bengal, India.
Verheyden, Dr. Cornelius, London.
Verjee, N. M. Suleman, Mombasa, Kenya Colony.
Woods, William, London.

The following candidates were balloted for and duly elected Fellows of the Society :—

Morgan, N. L., B.Sc., Quebec, Canada.
Pillay, G. Hurry Krishna, M.B.E, Rangoon, Burma.
Rayner, George Jabez, Victoria, British Columbia.
Kamla, Pat Sahai, London.
Starr, Mrs. Ida M. H., Easton, Maryland, U.S.A.

A paper on "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application in the Jute Industry," was read by Mr. John Francis Crowley, D.Sc., B.A., M.I.E.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

Friday, April 28th, 1922; Sir Robert Woodburn Gillan, K.C.S.I., LL.B., in the Chair.

A paper on "The Need for an All-India Gauge Policy" was read by Mr. F. G. Royal-Dawson, M.Inst.C.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

SEVENTEENTH ORDINARY MEETING.

Wednesday, March 22nd, 1922.

Sir Aston Webb, K.C.V.O., C.B., P.R.A., in the Chair.

The paper read was :—

THE LATE MR. HOLMAN HUNT'S EXPERIMENTS ON THE PERMANENCY OF ARTISTS' OIL COLOURS.

By Professor A. P. Laurie, M.A., D.Sc., F.R.S.E., H.R.S.A.,
Professor of Chemistry to the Royal Academy of Arts.

Of the work of painters of pictures in the first half of the nineteenth century, two from different schools, from the artistic point of view, have stood best the test of time, the pictures painted by the Pre-Raphælites and the pictures by W. P. Frith and others of a similar manner.

Of the Pre-Raphælites, Mr. Holman Hunt made continuous experiments on pigments and mediums, and through the kindness of Mr. Speed some of his experimental canvases have come into my hands.

There is, unfortunately, no record as to the history of these canvases, but I gather that they were hanging up or lying about in the studio, and it is quite obvious from their appearance that they have had every opportunity of collecting London dirt. It would not be fair, therefore, to record tests made under these conditions as proof that a particular pigment or medium was unreliable when used in painting a picture, and protected by varnish and also possibly by glass. Such information, therefore, as can be obtained from these canvases must be used with caution.

The first canvas, and the one of most interest is dated 7th May, 1860, and has written upon it "Canvas about the Colour of Parchment," "all without medium except where specified. C means copal, which in all cases causes the colour to be brighter, and sometimes is with the O.V. lighter in tone."

The pigments exposed are :—flake white; strontian yellow; lemon yellow; Naples yellow; cadmium yellow; yellow ochre; raw sienna; vermilion; Venetian red; Mars orange; Indian red; burnt sienna; Indian lake; burnt lake; cobalt yellow; chrome yellow; orange chrome; madder

yellow; Italian pink; crimson madder; madder carmine; carmine lake; Prussian brown; V.G. and cadmium; cadmium and emerald green; oxide of chromium; chrome green; emerald green; Veronese green; emerald oxide of chromium; verdigris; cobalt blue; French ultramarine; blue mineral; laques robert; Prussian blue; cadmium yellow; and a certain number of others which I have not been able to interpret.

The first remark to be made about this canvas is that all the pigments have gone down very much in tone, and that this darkening in tone has no relationship to the fugitive character of the pigment itself, but seems rather to have depended upon the transparency of the pigment, the opaque pigments having stood up best. The canvas has also become a dirty dark grey in colour. Now it is evident that this lowering in tone may be due to three causes:—the collection of dirt on the surfaces, a change in the pigment itself, and a darkening of the oil.

To deal first with the question of dirt:—If the pigments are washed with a neutral soap there is hardly any improvement in their appearance, and when examined under the microscope black particles are to be seen ingrained in the oil surface. This confirms the observations I have made before that the sooty particles of our modern towns seem to eat into and become ingrained in a linseed oil surface if it is not protected. An alkaline soap will remove this sooty layer restoring some of the brilliancy of the pigment, more especially in the case of opaque pigments, but doing little to brighten such a pigment as cobalt blue. It is also noticeable that on the whole the brilliancy of a pigment has been better preserved where mixed with flake white. Chinese vermilion is practically completely restored to its brilliancy by being washed with the alkaline soap, while cobalt blue is hardly improved at all, and chrome yellows only partially improved. The brilliancy of the flake white is completely restored, and the canvas recovers its original parchment tone. It is necessary to point out that special precautions have to be taken in washing with the alkaline soap, and special conditions adopted during the treatment.

An examination under the microscope of fragments of the more transparent pigments reveals the fact that the oil has become brownish yellow in tone, and the analysis of a portion shows that the oil contains lead driers. I suggest, therefore, as an explanation of the lowering in tone, which has taken place beyond and apart from dirt, that there has been a slow action of sulphuretted hydrogen on the lead driers which has darkened the oil. In the case where lead compounds are present in excess, such as flake white, the treatment with the alkaline soap restores the brilliancy because on account of the enormous excess of lead compounds present, the sulphuretted hydrogen has not been able to make more than a superficial attack. But in the case of a pigment such as cobalt blue there has been nothing to protect the lead driers from being attacked, and the consequent darkening of the oil in the case of such a transparent pigment has lowered the tone throughout the mass and it cannot be restored by superficial washing. This view is confirmed by the fact that the flake white is bleached by peroxide of hydrogen.

When allowance has been made for both the ingrained dirt and the darkening of the oil, we have next to ask ourselves whether the pigments themselves show change. This is obviously a somewhat difficult question to answer, but I will do it to the best of my ability. The madder yellows have disappeared. This is a preparation which has rightly long disappeared from the artist's palette, and Italian pink and crimson lake are also gone. Burnt lake has stood the test of time better, and Indian lake has changed much less than I expected. The madders have stood the test of time perfectly.

With the earth colours, allowing for the darkening of the oil, I do not think there is any other change, though I feel somewhat doubtful about the raw siennas which seem to be very dark in tone. Cobalt blue, blue mineral, which is an artificial ultramarine, and Prussian blue have all stood well, and other specimens of artificial ultramarine have also stood, with the exception of one sample labelled French ultramarine, which seems to have gone a bluish grey in tone. A green made apparently from cadmium yellow and Prussian blue has stood well. The oxide of chromium green, emerald green and Veronese green have all stood well, but mixtures of emerald green and cadmium have of course gone black. Verdigris has stood up much better than we might have expected. The vermilion is unchanged. All these results agree with the conclusion as to the safe

and unsafe pigments which are the outcome of experiments by Abney, Church and other observers.

We come now to more difficult and doubtful ground when we examine the yellows. The orange chrome has stood well. The samples of cadmium yellow, with one exception, have stood well. The chrome yellows have got distinctly greener in tone, and aureoline or cobalt yellow has gone a dirty brown in some places.

To deal first with the chromes, I have found specimens of chrome yellow on Constable's pictures which are as perfect as the day they were put on, and it is therefore difficult to say whether we should blame the pigment for the change of tone that has taken place on this canvas.

With reference to the cobalt yellows, there seems to have been a rising of oil to the surface which has got blackened with dirt, and it is also quite possible that sulphuretted hydrogen has had an injurious effect on this pigment. The experiments by Captain Abney proved it to be quite permanent in water colour, and therefore it is a little difficult to explain its apparent bad behaviour in oil. It evidently must in the meantime be placed on the list for further enquiry and it would be of interest to get information from artists who have used this pigment for a considerable period. It has so long been among the selected yellows in the artist's palette, that I doubt the conclusions to be drawn from this result.

With reference to the cadmium yellows there are other canvases of Mr. Holman Hunt's on which cadmium yellows appear, including this one, which have stood the test of time, but in one case on this canvas the cadmium has completely gone. It is labelled cadmium No. 1, and is, I imagine, a pale variety. I have long held the opinion that while the mid and orange cadmium are perfectly stable, the pale varieties are open to doubt unless they are manufactured by a process which necessitates their being raised to a temperature of some 500° or 600° C., in which case I believe them to be perfectly stable.

Strontian yellow and lemon yellow seem to have stood fairly well. The sample labelled Naples yellow is difficult to report on without a knowledge of the original tint. The only information given is that when put on it was lighter than the canvas. As is well known, what is called to-day Naples yellow is not the old oxide of antimony and lead but is a mixture imitating the tint which may or may not be made of permanent materials.

On the whole, therefore, the conclusion, as far as the pigments are concerned, to be drawn from this canvas is that the accepted list of permanent pigments as used to-day is reliable with possibly two exceptions, cobalt yellow in oil, and pale cadmium yellow, while it is certainly open to question if, on the whole, chrome yellow, when properly protected, should not be included in the artist's palette.

To return to the question of the darkening of the oil, I think the evidence is conclusive, that the excessive darkening which has taken place in this case is due to the presence of lead driers. It is, I believe, at the present day, the custom of the best artists' colourmen to grind in raw oil which, if properly refined by the mediæval methods, dries quite quickly enough for practical purposes without artificial stimulation. I have long suspected that the darkening of the latter 18th century pictures and the early 19th century pictures has been due to the use of lead driers in the oils and varnishes, and these experiments certainly confirm the view that no lead driers should be used on any account for artists' purposes. In many cases copal varnish has been mixed in as a medium, such specimens being marked with a capital C. There is no indication that the colours have been better preserved by this treatment.

The most serious defect is in the canvas, the ground in many cases having flaked off.

I hope to return to this question of the canvas, and also to give the results of the examination of the other canvases in a subsequent paper.

It is however satisfactory to learn that the present selected lists of artists' pigments are reliable with the possible exception of pale cadmium, and cobalt yellow, that the present practice of protecting by an easily removed mastic varnish is justified, and that the excessive darkening of the oil on this canvas is probably due to lead driers which are excluded from the oils and varnished according to the best modern practice.

DISCUSSION.

Mr. Walter F. Reid, in opening the discussion, said he had been present at a meeting of the Society at which Mr. Holman Hunt was in the chair, and on that occasion Mr.

Holman Hunt had referred to a number of experiments he was carrying out; but, personally, he never thought he would be able to hear a full account of those experiments from so competent a witness as the author. With regard to the method of carrying out the experiments, there was one thing, he thought, which was lacking from the scientific point of view: the medium with which the pigments were mixed was not known. He understood the paints were used in the plastic form in tubes; if that were so, and if some of the tubes remained, it might be possible to find out what the medium was.

Professor Laurie, interposing, said all the tubes had gone long ago; one could only assume that either poppy or linseed oil was used.

Mr. Reid thought that if it was not possible to identify the medium, half the value of the experiments was gone, because it was well known that many of the pigments used were perfectly permanent in themselves, and it was only when they were mixed with a medium, put on a painting and exposed to the air, that they deteriorated. The darkening of the oil was a subject which interested him very much, because for a number of years he had carried out experiments with regard to the oxidation and darkening of linseed oil. He had brought with him that evening a specimen of linseed oil which had been oxidised as long ago as 1878; it had been treated with about one half per cent. of lead driers and then oxidised and exposed to the air. It was now a thick viscous liquid, while its colour had changed from light amber to mahogany. Nothing whatever had been added to the oil except a small percentage of lead driers, such as were ordinarily used at that time. He could not accept the view that it was the lead driers which darkened the oil; he was in possession of an almost superfluous quantity of evidence to show that that was not the case. If sulphuretted hydrogen was allowed to get at the lead, lead sulphide was formed, which was grey in colour, and did not form a dark compound with the acids of linseed oil; if finely divided lead was suspended in the oil and sulphuretted hydrogen came in contact with it, a grey and not a brown substance was formed. He had oxidised pure raw linseed oil with the same result; it darkened on exposure to light. Even if the best linseed oil was used, it would darken in time. The mellowing of an old painting was thus clearly explained, and there was no need to look for any other reason to account for it than the darkening of the medium. Knowing that to be the case—and, personally, he was sure that it was so—it was no use trying to find a drier that would not darken. Moreover, the author appeared to have overlooked the point that most pigments were mixed with white lead. When there was a large quantity of lead in the pigment, it was unnecessary to worry about half per cent. lead driers in the oil, and in any case, the lead was not the cause of the darkening. An important point in connection with the super-oxidised oil—if he might so describe it—was that it was soluble in water and alcohol. Alcohol was one of the things used for cleaning paintings. Its action on the various soaps which were formed with the pigments used was a very complex one, about which it was impossible to generalise; but some of them were soluble in water and alcohol, which the original oxidised oil was not. That had an important bearing on the question of picture restoring, and he would like to support very strongly the view put forward by the author, that no solvents should be used on a picture. He was inclined to say that even water should not be used, although he did not know what could be employed as a substitute. If one examined the water afterwards—as he had done—one would find that soluble acid had come out of the oil into the water, and, therefore, water should not be used for washing. It was difficult to see what one could do to clean a picture; the best way, no doubt, was not to let it get dirty. If one possessed a picture painted by a good artist, it should be covered with glass, especially in our London atmosphere. A few days ago, he had taken part in a deputation to Sir Alfred Mond, who had promised to introduce legislation to prevent, as far as was possible under existing circumstances, the pollution of the atmosphere by smoke. If that could be done, and the atmosphere of London made as good as it was during the coal strike, the covering of pictures by glass might not be necessary; but at the present time, it was absolutely imperative. He had been interested to hear from the author that examination under a microscope revealed the way in which particles of soot became embedded in the paint, forming a pigment which was really more permanent than the others underneath. The choice of canvas was also an important point. Many of the prepared canvasses which were being used at the present time were shameful; most of them ought never to be used by self-respecting artists. It would be far better to do as did the old artists, and buy raw canvas, preparing it oneself with the best materials; the practice of buying canvas prepared with the cheapest rubbish that could be plastered down smoothly, was fatal to the life of any picture. He thought the true artist would always try to make his pictures last as long as possible. He strongly supported everything the author had said about restoring pictures; in most cases it was not restoration but destruction to which the paintings were subjected. He had never yet met a single restorer of pictures who could give a connected account of the process he submitted the pictures to. The nation possessed millions of pounds

worth of art treasures which could never be replaced, and which, if put in the hands of inefficient restorers, would be spoiled. No picture ought to be restored without some highly competent chemist, such as the author, being consulted.

MR. JOHN BATTEN said that in 1907 Mr. Holman Hunt was kind enough to invite the Society of Painters in Tempera, of which he (Mr. Batten) was at that time Secretary, to visit him at his studio to have a talk with him about methods of painting. He had made a few notes ot that interview, which he thought might prove interesting. Mr. Holman Hunt at that time was nearly blind, and to a man whose eyes had been his very life, that must have been a great tragedy; but he showed no sign of self pity, and seemed as cheerful as a boy. The notes were as follows:—"Holman Hunt was painting 'The Hireling Shepherd' at the same time that Millais was painting 'Ophelia' They both made use of the same method in painting the brillant portions of the pictures Flake white, that had had all excess of oil sucked out of it by being laid on paper overnight, was laid on, and the colour painting was done over it." Extract from Mr Holman Hunt's letter of November 11th, 1907, to the Secretary of the Society of Painters in Tempera:—"The use of iodine scarlet was in the painting of the cloak of Julia in the picture of 'The Two Gentlemen of Verona' now at Birmingham. The modelling of this was done with white and some blue on the outlines of the velvety receding folds and with umber and perhaps cologne earth in the deepest shadows of the nearest folds This, when dry, I varnished with copal unmitigated except for some admixture of rectified spirit of turpentine, and when this was quite hard I painted the iodine scarlet, leaving the preparation to show through, as one would with water colours, in the strongest lights, and finally when this had become quite hard I worked over all, where necessary, with semi-transparent colours, again using copal, and so left it complete. This was in the year 1851, and now it is a good example of what 'locking up' fugitive pigments in varnish may do." Later in the same letter, after some passages in disparagement of mastic varnish, especially when used over ochres and umbers, Mr. Holman Hunt writes:—"I think I omitted to state that I had found in the correspondence of Venetian painters that the varnish they used was the varnish of musical instrument makers, which, of course, had to dry like enamel, not affected by the heat of the hand, as mastic varnish certainly would be. This was one reason for concluding that they employed either amber or copal for their paintings." Millais and Holman Hunt used flake white which had had all excessive oil sucked out of it, and the colour painting was done over it while still wet with light touches, so as not to disturb the white ground. The operation had to be finished at one painting, and could not be satisfactorily retouched. The medium used by both consisted of copal varnish, poppy oil and rectified spirit of turpentine. Holman Hunt used equal quantities of each; Millais' medium was rather thicker. Copal varnish and poppy oil did not mix readily, but could be made to do so by heating and by the addition of spirits of turpentine shortly afterwards Maddox Brown painted "Christ washing the feet of Peter" and used the same method. Holman Hunt and the early Pre-Raphaelites certainly put their faith in copal varnish. He did not know who supplied it, but it was of wonderfully good quality It was characteristic of nearly all paintings by the Pre-Raphaelites that they preserved their purity and did not fade. One reason for that was the fact that all the excessive oil was sucked out of the flake white, as he had already mentioned, so that there was no excessive oil to darken, and the other reason was the excellence of the copal varnish used. As far as permanence of colour was concerned, the Pre-Raphaelities succeeded absolutely, but if one closely inspected their paintings, his own feeling was that their surface quality was unpleasant. They had nothing of the achievement of the Italian or Flemish painters in that respect. A curious thing about the Pre-Raphaelites was that, although they set out to paint in an ancient and foreign manner, they actually achieved the most characteristic modern English painting in existence.

MR. NOEL HEATON said he would like to emphasise what the previous speaker had said as to the importance of the medium. The durability of an oil painting depended far more on the durability of the medium than it did on the durability of the pigments. He had always understood that Holman Hunt did not paint in straight linseed oil, merely taking his pigments, ground into a paste with linseed oil, and using them straight away—as did the average painter of to-day—but aimed at using the minimum possible quantity of oil. He understood, moreover, that he employed a thickened linseed oil to a certain extent. Personally, he believed the idea that the oil painters of the Van Eyck school painted in straight linseed oil, was a mistaken one. The more he studied their pictures the more he came to the conclusion that they must have used some such medium as Holman Hunt evolved, a medium which was very much thicker, and to a certain extent less tractable, than the medium of to-day. It could be well understood why, if he was right in his surmise, the methods adopted by that school of painters fell into disuse; the average painter would not go to the trouble of using a comparatively intractable medium, any more than the ordinary artist of

to-day would take the enormous amount of trouble the Pre-Raphaelites did in experimenting to ensure the durability of their paintings. The present-day practice was to leave the selection of materials to the artists' colourman, and hope for the best. He agreed with Mr. Reid as to the darkening of the oil. It was not necessary to assume the action of sulphuretted hydrogen on the lead contained in the linseed oil, in order to account for the darkening which took place At the same time, he quite agreed with the author that it was a disadvantage to have lead dissolved in the oil. He had spent many years in making artists' colours, and, as far as his experience went, during the time he was connected with the industry he did not know of any manufacturer who used anything but pure refined linseed oil, or in many cases refined poppy oil, for grinding the pigments. It was quite unnecessary to use lead driers, because the artist did not require his paint to dry in the same way that the house painter did. The longer the picture remained open the better it was for him, because it gave him greater opportunity of working on it. In ordinary painting, of course, driers were added because it was necessary to get the work finished quickly, and he could only assume that in the early days some artists' colourmen may have used them because they did not know enough to differentiate between the two classes of work From the list the author had read out, it appeared that Holman Hunt's palette was practically complete, and included all the pigments available at that time. He thought most chemists would agree with the author's comments on the pigments mentioned. With regard to cobalt yellow, which the author said required further investigation, the late Sir Arthur Church, in the first edition of his book, regarded it as a perfectly permanent pigment, but he believed he materially altered his view on that in the light of further experience. It was a substance which, in theory, one would expect to be less permanent in oil than in water, owing to the fact that oxidation might take place. He could not see any reason why raw sienna should darken; it seemed to him that the only reason why it lost its colour was that it was a fairly transparent pigment, and the same action took place with it as the author described as occurring with cobalt blue. The cleaning and restoring of pictures was a very burning question at the present time, and ought to be ventilated. He thought it was absolutely necessary for the public generally, to whom the national collections really belonged, to see that no tricks were played with them. Like Mr. Reid,, he had been trying to find out what the restorers actually did in "beautifying" (as the old churchwardens called it) the paintings they dealt with. He could not help thinking that in some cases they simply put fresh paint over the top of the original, so that in time the work of the original artist would be entirely lost beneath the efforts of the cleaners.

The Chairman (Sir Aston Webb) said that both the paper and the discussion had been very interesting. The meeting had been honoured by the presence of Mrs. Holman Hunt, who would feel, he hoped, pride and satisfaction in hearing the remarks which had been made as to the way in which her husband's pictures had lasted. Holman Hunt's picture of Claudia and Isabella had recently been secured for the national collection at the Tate Gallery, and all those who had seen it marvelled at its wonderful condition. At the exhibition which had just closed at the Royal Academy, there were also many pictures painted, some of them, fifty years ago, which were still in very good condition, although some half dozen had cracked badly. Sir Joshua Reynolds actually destroyed two very valuable Old Masters he possessed in an endeavour to discover the secret of their lasting quality, but he did not altogether succeed, because several of his own pictures had gone rather badly. The meeting appeared to be entirely of opinion that the present system of restoring pictures was unsatisfactory. That being so, and the experts, apparently, agreeing on the point, he thought it was time action was taken to enquire into the whole matter. It was well known that pictures in the national collections were restored from time to time, and he thought the public had the right to know in what way that restoration was carried out When painters met together, their two chief topics of conversation appeared to be the colours they used and the restoration of pictures They seemed to hold many different opinions on the latter subject. He had been told, however, of one matter in that connection which he thought was of the greatest importance, namely, that many artists of the eighteenth and early nineteenth centuries used glazes with their varnish, and a good deal of the last touching of their pictures was done with glaze mixed with varnish. If that was so, when the varnish was removed the glaze would come off with it, and in that way one would lose a great many of the original touches of the Master himself. He had also been told that Crome and Claude, and artists who painted in that manner, got a great deal of their effect by varnish; the warm colour of their sunsets was, to some extent, obtained by that means. If the varnish was removed, therefore, as had been done in some cases, no matter how much care was taken not to remove any of the paint, a certain amount of the artist's effect would be spoiled. He did not know by whom such an enquiry as he had suggested would best be conducted; possibly the Government might undertake it. Mr. Reid had mentioned the deputation which waited on Sir Alfred Mond with regard to the smoke nuisance in London.

That question had been taken up by an independent Society, who had at last prevailed on the Government to appoint a Committee which had made very useful recommendations, to which the Government had promised to give legislative effect; and, if they did so, the amount of dirt and smoke in the atmosphere should be appreciably reduced. As Mr. Reid had said, unless pictures were protected by glass they did get into a very bad state. He himself had had to deal with a picture which had hung in Newgate Street for about two hundred and fifty years. It was a large painting, about eighty feet by twelve, and depicted Charles II giving prizes to Christ's Hospital boys. Nothing appeared to have been done to it during that time, and all one could see was some white patches, which were the faces and hands of the boys. When the school removed to Horsham, the picture was washed and proved to be in very good condition; the dirt had not done as much harm to it as might have been expected. In conclusion, he would like to add his testimony to the very excellent and practical character of the author's paper. The author's services at the Royal Academy were very valuable: he taught the students how to give permanence to their work. In the case of some of it, it was perhaps hardly necessary that it should be too permanent; but if modern artists were able to make their pictures permanent, it would largely be thanks to the author. He proposed a very hearty vote of thanks to Professor Laurie for his paper.

The vote of thanks was carried unanimously.

Professor Laurie, in reply, said he was quite prepared to admit that, given certain conditions, linseed oil which contained no driers would darken, and he was not sure what conditions were necessary to ensure its not doing so; but, if driers were present and were attacked by sulphuretted hydrogen, the colour would most certainly darken. The first thing, therefore, he thought, was to keep the lead driers out; once that was done one could see what other tricks the oil was going to play. He agreed with Mr. Batten that Holman Hunt and Millais painted on flake white. They took out the oil and added a little copal varnish, painting on the surface while it was still wet. He did not think they extracted the oil from the other pigments used, but they always mixed a little copal varnish with them. There were different views as to the desirability of that. As far as his own experience went, the rate of fading appeared to be about the same whether copal was used or not; but the use of copal produced a kind of hardness of surface to which many artists objected. Possibly his remarks as to the medium used by the early oil painters had been misunderstood. He was concerned with the point as to whether they used egg emulsion, or oil, including in the oil a certain amount of varnish. It was probable they did mix with their oil what would be regarded to-day as very tender varnishes, but it was very difficult to say. In stating it as his opinion that they used oil, he had not meant to exclude the possibility of varnish being added.

The Secretary had suggested to him that it would be a good thing if the Society took up the question of the cleaning of pictures, and he thought it was time that was done. Those who had expert knowledge in the matter would be glad to experiment and see how far one could safely go. Whether Holman Hunt's oils darkened because of sulphuretted hydrogen or not, they did darken. The first thing to be considered was whether a darkened oil could not be bleached without using a solvent. The "Mystery Man" business in cleaning pictures had got to be stopped.

Mr. A. Elphinstone said that twelve years ago he carried out an experiment which consisted of laying down about half-a-dozen different mediums on very carefully prepared canvas. He used pure linseed oil, pure poppy oil, picture copal varnish, and so on. To-day he found that the pure linseed oil, laid without any pigment over perfectly dry flake white, had turned only slightly yellow, and the same applied to poppy oil. There was no lead in either of those oils. Those experiments showed that linseed oil, if used thin, but sufficiently thick not to lose its gloss, did not become much darker after 12 years. He had also laid down pure linseed oil mixed with copal varnish and pure poppy oil mixed with copal varnish, and they had turned distinctly darker, though subjected to the same conditions, than copal varnish by itself or pure linseed or poppy oil used alone. Did any known chemical action take place when copal varnish was mixed with the oils which would account for the darkening? His experience was that chrome yellow stood well, and probably better, than cadmium.

Professor Laurie said the objection to using linseed oil as a varnish was that it would collect dirt which would get engrained in it, and that was why one wanted a varnish which could be taken off. Cobalt yellow was such a complex substance that chemists would hardly expect it to be permanent, but there seemed to be no question of its permanence in water colour, at any rate. He could not explain why a mixture of oil and copal varnish should darken more readily, but of course it was notorious that copal varnish did darken more readily than linseed oil, and that was one of the objections some artists had to using it as a medium, although others had used it successfully.

The proceedings then terminated.

CORRESPONDENCE.

CURRENCY AND DISCOUNT.

The paper by Mr. Oswald T. Falk, which was read and discussed on March 15th, gives rise to many most important considerations. One notices the great differences of opinion expressed by gentlemen all of great experience and capacity. I therefore venture to suggest a remedy for most of the difficulties of currency and discount. The remedy is that all the laws regulating currency should be abolished, leaving the people free to adopt such currency as they like, and to have as much as they want. I do not propose at present to forbid the Government to make an issue of metal and paper currency as much as the market will take, but I propose that any person or company should be allowed to issue notes of any kind they like, subject of course, to this, that no issue of notes, or metal currency, must have any such resemblance to Government notes and metal currency as to make it reasonably practicable to substitute these private notes for Government notes. Of course, nobody would take the notes of a private person or company unless he had confidence in the value of the notes, etc., but if all legal restrictions were removed, the great banks would gradually issue their own notes, and also as gradually, confidence in these notes would become general among increasing numbers. At the present moment this country (like most other countries) suffers from the monopoly of the issue of currency which is the result of a series of laws culminating in the Bank Act of 1844, the effect of which is to cause panics and also to prevent the development of industry.

I dare not ask for space for full explanation (I would refer your readers to the excellent book by Henry Meulen entitled, "Industrial Justice through Banking Reform," published by Richard J. James, 10, Ivy Lane, Paternoster Row, E.C.).

ARNOLD LUPTON.

OBITUARY.

LIEUT.-COL. SIR JAMES HAYES SADLER, K.C.M.G., C.B.—The death of this well-known administrator occurred in Brittany on April 21st, at the age of seventy. He received his first military commission in 1870 and after serving for some six years in the Indian Staff Corps joined the Foreign Department of the Government of India, gaining his earlier experience as a political officer in Mahi Kantha and Baroda. In 1892 he went to Muscat as Political Agent and in the following year was selected to be Acting Resident and Consul-General in the Persian Gulf. Subsequently, he was an Assistant Secretary to Government, and his next appointment was the important one of Political Agent for the Somali Coast. He retired from the Indian service shortly after his arrival in Somaliland, in 1897, but remained there till 1901 as Consul-General, when he became Commissioner in Uganda. From 1905 to 1909 he was Governor of the British East Africa Protectorate and from 1909 to 1914 Governor of the Windward Islands.

In 1902, while temporarily in England, he took part in a meeting of the Colonial Section (now the Dominions and Colonies Section) when, under the chairmanship of the celebrated explorer, Henry M. Stanley, a paper entitled "To the Victoria Nyanza by the Uganda Railway" was read by Commander B. Whitehouse, R.N. Sir James was elected a member of the Society in 1903.

FIBRE RESOURCES OF COLOMBIA.

Colombia's vast stretches of lands covered with fibre plants have been of little value in the past, but, according to a report by the United States Vice-Consul at Barranquilla, recent experiments have resulted in the perfection of a machine that will reduce to fibre the leaves of plants of the wild pineapple family, from which are produced some of the finest vegetable fibres known—Bromelia Sylvestris and Bromelia Pinuela. The former fibre is divisible into one ten-thousandth of an inch. It has as much tensile strength as flax. It fully as well resists the action of water, and it takes dye perfectly and with a good gloss. The Indians used it for fish nets and their mummies were wrapped in it. Some of these mummy urns recently opened showed the fibre in a good state of preservation. Bromelia Pinuela has also been long recognised as a valuable plant fibre, and large sums have been spent in efforts to perfect means for its mechanical reduction. Owing to its greater and more accessible supply in Colombia, this will be the one first to be produced in commercial quantities.

There are many groups of the Bromelia or wild pineapple family. They are known to the natives as Pita, Maya, Chivi-Chivi, Pinuela and Penguin, their value as to fibre and yield being in that sequence. The Pita leaf is about 4 inches wide and 8 to 12 feet long. The others grade down to Penguin, which is about 3 inches wide and 4 to 6 feet long. Penguin is native to Jamaica, Cuba, and other West India Islands. The others grow prolifically from 10° north to 10° south of the Equator.

These plants are impervious to weather conditions, and because of their rapid growth are not choked down by other vegetation, as frequently happens to the hard-fibre plants, such as henequen. There are vast tracts along the mountain foothills, and there are other

immense areas growing on periodically submerged lowlands. The supply and its possibilities will meet any possible future demand, even to the extent of a hundred thousand tons annually. The largest tracts in Colombia are reached by water.

Added to the fact that the supply is so bountiful is the consideration that the machine for reducing to fibre is simple and can be produced for about £100. Each machine will be capable of producing 250 pounds of fibre per day. From a ton of leaves, the gathering of which will cost about £2, there are produced 500 pounds of fibre. Labour in the interior for handling the machines can be obtained cheaply, and the production of oil in Colombia will furnish cheap fuel. The machine is producing a fibre of about 18 to 24 inches in length, with a shorter length fibre which automatically separates from the longer, of about 5 inches, for use in the manufacture of linen paper. A third part which automatically classifies itself seems to be a good food for live stock, but on account of its resilience is being bought in Barroquilla for use in upholstering.

WATER POWER IN INDIA.

Some very interesting material both for the general student and for those interested in industrial development, is contained in a publication entitled "Triennial Report with a Preliminary forecast of the Water Power Resources of India, 1919-1921," compiled by the Hydro-Electric Survey of India. In an introductory chapter the report comments upon the generally poor attempts throughout the Empire to utilise this source of energy as compared with Europe and North America, where 18 and 17.3 per cent. respectively of the available power have been developed. The figures for North America include Canadian results, so that these are not given in the returns for the British Empire, which stand at 1.7 per cent. In India the proportion falls even lower. The report says that the probable water power of India for "maximum development" is some 12,680,000 kilowatts, equal to 21½ million water horse power, of which only 1½ per cent. is developed or in the course of development.

The report, in making a distinction between the estimates of resources, says: "No endeavour has been made to assess the discontinuous power of individual sources which may be available for six to eight months in the year. In every country this is much greater than the continuous power available on minimum flow in the worst years, but in India, where the wet season is confined to a few months, the excessive power available during the time that the effect of the monsoons is still felt, is beyond any attempt at calculation; monsoon storage schemes are an exception, for here the whole available power is averaged throughout the year and the maximum power is also the actual. Furthermore, when the hot weather begins, there is a great rise in the discharge of all snow-fed rivers, which lengthens the discontinuous period. The Dominion Water Power Branch of Canada, which has taken up the question exhaustively, shows that the "power for maximum development" dependable for six months is very nearly double that obtainable on "ordinary minimum flow," not absolute minimum flow as in this report. "Ordinary minimum flow" is defined as being "based on the averages of the minimum flow for the lowest consecutive seven day-periods in each year over a period for which records are available." The "estimated flow for maximum development" is based upon "the continuous power indicated by the flow of the stream for six months in the year."

After describing the method followed to determine this flow, the report states that as far as it is in any way possible to indicate at present the total power shown amounts to 582,000 K.W.s or 7,400,000 electrical horse power; and as the basis is minimum to continuous power, the figures represent kilowatt years. In distribution among the chief divisions of India, Burma, North West Frontier Provinces and Punjab have the largest proportions, being almost equal. Bengal and Bombay follow at a short distance, while Assam, United Provinces and Kashmir are a long way behind, with the "rest of India" possessing only a very small share. The different projects in these areas, however, have not been examined with an equal degree of thoroughness, attention having been given most prominently to the United Provinces and Bombay. In Bihar, Bengal and a number of other provinces, only a very meagre examination has been carried out, whilst the work of plant installation has been principally in Bombay and Mysore.

A remarkable table is that which gives a summary of the probable minimum continuous water power in India. In quite a large area, including Assam, Baroda, Bihar and Orissa, Central Provinces and Berar, Central India, Cochin, and Coorg, Gwalior, Rajputana and Sikhim, the water power now developed is *nil.* In some of these areas, it is true, the probable total K.W.s is exceedingly small, as in Baroda, Central India and Rajputana, which are emphatically in the dry zone. In other divisions however, the probable amount is fairly large. In Assam, for example, it is 414,000 K W.s, of which 109,000 are obtainable in areas investigated, but not developed. In Bihar and Orissa, the corresponding figures are 62,550 and 12,550, and in the Central Provinces they stand at 137,560 and 13,700. These results are disappointing, as showing how little use has been made of natural opportunities; and the figures

for these areas in which some development has taken place, with the sole exception of Jammu and Kashmir and Bombay, afford very little consolation. In Bengal for example, out of a probable total for minimum continuous water power, amounting to 669,850 k.w.s, only 600 k.w.s are in a developed state, 14,250 are in areas investigated, but not developed, while the largest portion of the Province remains to be investigated. Worse still are conditions in the North West Frontier, where, with a probable total of about 1,000,000 K.W.s, only 250 are developed. In the United Provinces, including the Canals, the figures are 403,370 and 4,330 respectively, but in this instance a very large proportion of the source has been investigated. Burma also shows a very backward condition, the actual development being 3,370 K.W.s out of a probable total of nearly a million. It may be remarked that the plant under construction is only for 55,640 K.W.s, of which 50,000 are in Bombay, 4,500 in Mysore, 1,000 Gwalior, and only 140 in the United Provinces. Summing up the figures for all the provinces, the report states that of a probable total, 5,582,300 K.W s only 213,140 are now dedeveloped, and 3,017,000 are put down to areas and sites which have not yet been investigated.

Power in Bengal.

Turning to conditions in Bengal, the report says that water power developed at present "consists only of the pioneer installation at Darjeeling." The Municipal Hydro-Electric Supply is obtained from three small nullahs, tributaries of the Rangeet and Tista Rivers. The original development in 1896 utilised the hospital jhora and Kotwali jhora by means of open channels meeting above the confluence. Later a third nullah was brought in, and finally "the hospital jhora was tapped at the point higher up the stream, and an upper power house was built." More, however, can be said of the sites which have been examined in Bengal. In this connection the report says: "Hitherto the only site in Bengal of which the examination has been definite are in the Dooars tea planting district, in the Jaldaka and neighbouring streams. The possibility of development here turns almost entirely on the question of firing the tea leaf electrically"—a process which is discussed by the report in a separate paragraph. Altogether there are three sides, one being the Jaldaka river, the second a small project in the Moortee River, and the third in the Ne Chu (or Thodi) River. Among known sources, whose possibilities, however, have not been ascertained, are the rivers in the Darjeeling district and the Karnaphuli River, Chittagong. It may be mentioned also that the resources of Assam, both developed and undeveloped, as also the actual position and the possibilities in other provinces, are carefully described, while special prominence has been given to the canal falls in the Punjab. In this province also the three great sides examined, the Anu, the Sutlej at Nangol and the Sutlej River project have come in for their share of attention, the Anu Khad scheme being of special interest to residents of Simla, where the demands for a hydro-electric station have become more urgent.

The report does not pretend that it has given an exhaustive account of existing possibilities or that it has made an accurate forecast of the water power of India, for the author says: "Even now any such attempt is of necessity largely guesswork."

SOUTH AFRICAN DIAMOND MINING INDUSTRY.

The estimated value of the diamonds produced in the Union of South Africa during 1920 constituted a record for the industry. The value of the mined, alluvial, and débris-washed diamonds totalled for the year the sum of £14,762,899. The bulk of this amount, or £12,289,602, came from the mines, £2,441,440 from alluvial mining, and £31,867 from débris washings The previous record year was 1919, the output being valued at £11,734,495. Prior to 1918 the high-water mark was reached in 1913, when diamonds were produced to the value of £11,389,807.

The 1920 output aggregated 2,545,017.47 carats, of which 2,312,436.55 came from regular mines and 221,460.17 from alluvial mining; 11,120.75 carats were recovered from débris washings. It is to be noticed that production in the six years 1915-20, has been practically constant, and in the last three years of the period has fluctuated approximately by only 50,000 carats. The year 1910 is still the record by volume for the industry, 5,456,558 carats being produced.

While production value in 1920 constituted a record, the sales of diamonds fell below the total of 1919 by £3,411,257—from £13,739,662 to £10,328,405. This decrease is accounted for by the large drop in the volume of sales, which were only 1,765,993.82 carats as compared with 1919 sales of 2,648,931 carats. The sales total would have been even less in value except for the increase in the price realized, which was 117*s*. in 1920 against the 1919 figure of 101*s*. per carat. This high figure reflects the effect of abnormal conditions on prices, as the price realized per carat in 1917 was 51*s*. 1*d*. and in 1918 was 54*s*. 9*d*. That these high price stimulated production is evident in that there were 19 mines producing in the Union in 1920, compared with 16 in 1918 and 11 in 1917.

In a report dealing with the diamond industry, by the United States Trade Commissioner at Johannesburg, from which the foregoing figures have been taken, he points out that the fluctuating character of the industry is indicated by the fact that while the value of diamonds from

mines rose in value from 75*s*. 9d. in 1919 to 106*s*. 3*d*. per carat in 1920, the alluvial diamonds declined from 261*s*. 6*d*. to 220*s*. 6*d*. On the other hand, when the jump in the value of the alluvial output between 1918 and 1919 was from 134*s*. 6*d*. to 261*s*. 6*d*. the mine output was only increasing from 51*s*. 5*d*. to 75*s*. 9*d*.

In view of the special manner in which diamonds are marketed through the Diamond Syndicate, it is interesting to note the difference between the production and sales figures. In 1920 sales by volume were 779,024.65 carats under production. In 1919 sales were 60,813.95 and in 1918, 104,572.45 carats above the output. In 1917 the position was reversed and production exceeded sales by 586,206.90 carats, while in 1916 such excess was 54,383.33. Taking this five-year period, the total production of diamonds exceeded the total sales by 1,254,228.48 carats. During this same period the value of the output exceeded the realization value of £4,114,968.

The production within the Union is divided, in order of importance, among the Cape, the Transvaal, and the Orange Free State. The Cape contributed 1,364,706.25 carats, of which 1,258,129 were from the Kimberley mines. The Transvaal production was 905,297.05 carats, practically the whole of the 782,557.30 mine diamonds being the output of one mine. The share of the Orange Free State was 275,014.17, of which 269,178 carats were from the nine mines in that district.

The importance of the diamond industry to South Africa is reflected in the purchases of mine stores. The returns for 1919 show that the mines consumed stores in that year to the value of £1,058,050. The figures for the past few years are as follows: In 1918, £747,142; in 1917, £688,801; in 1916, £350,485; in 1915, £139,521; in 1914, £969,325; in 1913, £1,645,219. in 1912, £1,466,151; and in 1911, £1,450,127. It is evident from these statistics that during the past few years purchases have not come up to the pre-war figures despite the higher price levels that now prevail. Some of the principal items in 1919 were: Coal, £185,063; dynamite, etc., £120,481; candles, £22,097; belting, £9,928; safety fuse, £34,250; hand tools, £11,991; lubricants (oils), £21,756; machinery and machine tools, £33,558; rails, sleepers, etc., £37,955; sheet steel, £24,146. Of these items, all of the coal and dynamite and practically all of the candles were produced in the country itself.

ADVERTISING IN SOUTH AFRICA.

Entirely different methods of advertising should be followed in the different Provinces of South Africa, according to advice furnished by the United States Consul at Johannesburg, As an example, the Transvaal may be regarded as a huge mining district, Johannesburg being the centre. Money circulates freely, and business is carried on in a so-called rough-and-ready manner. The characteristic of buyers is that they require a concise, detailed account of the article and a fixed price. In the Cape Province, however, the people are more conservative, probably more thrifty, but do not have the same amount of money to spend. Cape Province has been settled longer and conditions there approach those of an older civilization more than do those in the Transvaal. Cape Town is the centre of whatever art there is in South Africa and consequently artistic advertising is of greater value in the Cape Province than in the more recently settled portions of the Union. Under these conditions it is evident that a waste of money results in sending out copy for general use throughout the country.

There are other points which should be borne in mind when placing advertising in South Africa, such as differences in climate of the various Provinces, the South African's lack of knowledge of many things which are in common use in European countries and the United States, and the inferior quality of paper used in publications which will not give good impressions of fine blocks.

COTTON GROWING IN THE ARGENTINE CHACO.

Many efforts have been made by public authorities and by private enterprise to stimulate the growing of cotton in the Chaco Territory of Argentina and on other suitable lands in the Republic, but the stimulus of high prices proved more effective than other means of encouragement, and cotton acreage increased to a measurable extent during the last few years.

The first cotton gin is said to have been brought into the country in 1863 as a result of attempts made during the American Civil War to introduce cotton growing into Argentina. At various times the distribution of free seed and exemption from taxation have been resorted to without appreciable results; prizes have been offered, and in various competitions good samples have been submitted. However, writes the United States Consul at Rosario, not much headway was made until after the outbreak of the war in 1914. The stimulus of war prices on the cotton industry is reflected in the acreage planted to this crop which for the five years 1915-19 as follows: 1915, 8,414 acres; 1916, 7,001 acres; 1917, 26, 847 acres; 1918, 29,947 acres; 1919, 34,200 acres.

The growth of this industry in the Chaco Territory alone is indicated by the following statistics (showing hectares cultivated), compiled by the State Railway officials: 1918-19, 5,541 hectares; 1919-20, 9,010 hectares; 1920-21, 22,920 hectares. (Hectare equals 2.47 acres.)

Private estimates ascribe 12,000 hectares to the Province of Corrientes in 1920-21, and a small amount has been grown experimentally in other Provinces.

Many varieties have been tried, including Egyptian, Sea Island, Russell, Georgia, Petterkin, Culpepper, Simpkins, Manila, and Texas Wood. The Egyptian cotton did not prove adaptable, and the best results have been obtained with Upland short staple. Most of the cotton now raised is known simply as Chaco cotton, which is understood to be an acclimatised variety of Russell cotton. It is a clean white cotton with irregular fibres from an inch to an inch and a quarter in length.

Planting is done during September and October in the Chaco and in Corrientes, and picking begins about the middle of February. Ten kilos of seed are estimated as necessary for seeding one hectare, and the yield is estimated at between 1,000 and 1,500 kilos. The yield of seed per hectare rapidly decreases as the land becomes exhausted.

As a result of the high prices obtained in 1920 a considerable extension of acreage occurred and in some districts, as for instance in the county of Goya, Corrientes, tobacco culture was abandoned in favour of cotton growing, while in many other counties in the same Province cotton acreage was increased.

Exports of raw cotton were included for the first time in 1920 in official reports of exports of the country's products. The quantity shipped during the year amounted to 4,120 metric tons; the annual exports during former years are unofficially estimated to be 3,065 bales in 1912, 1988 bales in 1913, and 1,242 bales in 1914. In comparing these figures, however, consideration should be given to the much larger importation of raw cotton and to the enormous importation of cotton yarn and textiles. Native cotton is used for the domestic manufacture of absorbent cotton, for mixing to some extent with other textile fibres, for match stems, and as waste, and is sold by sample instead of by grade. On account of its short fibre it can scarcely be considered a competitor with the imported cotton.

The difficulties of extending cotton production in Argentina consist largely in the lack of labour and the unfavourable climatic conditions of the northern valley lands. The land available is practically unlimited, but it will be necessary to clear it, combat semi-tropical conditions, establish settlements, and import labour before the industry can become well established.

An annual competition has been established by the Museo Agricola de la Sociedad Rural in Buenos Aires for the display of samples of native cotton, and in the 1920 competition 75 growers applied for representation and 41 submitted samples which comprised Chaco, Texas, Wood, and Russell varieties.

GENERAL NOTES.

INSECT PESTS OF RAW COCOA.—Most foodstuffs, when stored, are liable to be attacked by insects, and the damage thus caused amounts in the aggregate to millions of pounds every year. Perhaps the best known pest of this kind is the grain weevil, which destroys enormous quantities of wheat and other cereals, particularly in countries such as Australia and Canada, where vast stocks of grain are stored while awaiting shipment. The depredations of such insects extend even to raw cocoa and it has been estimated that the proportion of "grubby" beans in the world's production of cocoa is on the average from one to two per cent. This subject was considered at the Rubber and Allied Industries' Exhibition, held in London this year, when Mr. A. W. Knapp, of Messrs. Cadbury Bros., Ltd., read an interesting paper on Insect Pests in the Cocoa Store, which is printed in the current number of the Bulletin of the Imperial Institute. The most frequent pests are the caterpillars of small moths, particularly those of the Mediterranean flour moth, which are often found in mills and granaries; minute beetles too are commonly present. Various methods have been tried for destroying the insect attacking the cocoa, including fumigation with chemicals and spraying with insecticides. The most effective method, however, appears to be the application of heat, since this kills the eggs as well as the larvae and adult insects, whilst, provided the temperature of 160°F is not exceeded, the cocoa is not detrimentally affected.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.—An Exhibition of Contemporary British Architecture will be held in the Galleries of the Royal Institute, 9, Conduit Street, W.1., from November 1st to December 16th, 1922. All architects in the British Empire are invited to submit their work. Exhibits may consist of photographs, elevations, perspective drawings and small scale plans. The last day for the receipt of drawings and photographs will be October 7th, 1922. The Exhibition will be open to the general public (free) between the hours of 11 a.m. and 6 p.m.

SILK CULTIVATION IN BRAZIL.—The Brazilian Ministry of Agriculture, through its sericulture experiment station at Barbacena, in the State of Minas Geraes, has made sufficient headway for the incorporation of a company to erect a modern silk factory at Campinas, Sao Paulo, writes the United States Assistant Trade Commissioner at Rio de Janeiro. Mulberry trees are grown with considerable success in Brazil, and silk worms have so far escaped serious epidemics. The quality of Brazilian silk is claimed to be of the best, withstanding all unfavourable effects of washing.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

MAY 10.—MAJOR PERCY A. MACMAHON, R.A., LL.D., ScD., F.R.S., "The Design of Repeating Patterns for Decorative Work." SIR MARTIN CONWAY, F.S.A., M.P., in the chair.

MAY 24.—GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland." SIR GEORGE T. BEILBY, D.Sc., LL.D., F.R.S., Director of Fuel Research, in the chair.

MAY 31 (at 3 p.m.) — LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

MAY 26.—SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture."

JUNE 23.—F. W. WOODS, C.I.E., late Chief Engineer, Irrigation Department, Panjab, "Irrigation Enterprise in India."

Date to be hereafter announced:—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION.

FRIDAY, JUNE 9, at 4.30 p.m.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.*

MONDAY, MAY 8..Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. R. Bryce, "The Klagenfurt Plebiscite."

University of London, King's College, Strand, W.C., 5 p.m. Prof. G. B. Gray, "The Place of Sacred Gifts in Hebrew Practice and Thought." (Lecture I.)

At Bedford College for Women, York Gate, Regent's Park, N.W., 5.15 p.m. Prof. F. Baldensperger, "Une Destinée Littéraire Anglo-Française: Alfred de Vigny." (Lecture II.)

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Brewing, Institute of, at the Institute of Chemistry, 30, Russell Square, W.C., 8 p.m. Mr. A. H. Paul, "The Delivery of Beer in Bulk."

Royal Institute, Albemarle Street, W., 5 p.m. General Meeting.

Chemical Industry Club, 2, Whitehall Court, S.W., 8 p.m. Dr. E. F. Armstrong, "Chemical Progress: Some Impressions of 25 Years."

TUESDAY, MAY 9..Petroleum Technologists, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. E. H. Cunningham Craig, "Kukkersite, the Esthonian Oil-Shale."

Photographic Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Prof. Svedberg, "The Interpretation of Light Sensitivity in Photography." (Hunter and Driffield Memorial Lecture.)

Anthropological Society, 50, Great Russell Street, W.C., 8.15 p.m. Captain M. W. H. Simpson, "Some Ethnographical Researches among the Berbers of Algeria."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Lord Lee of Fareham, "The Washington Conference."

Anglo-French Society, Scala House, Tottenham Court Road, W., 6.15 p.m. M. M. Thiéry, "Le Drame en Vers, Henri de Bornier et François Coppée."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. Sir Arthur Keith, "Racial Problems in Africa." (Lecture III.)

WEDNESDAY, MAY 10..People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Prof. C. S. Myers, "Industrial Life, its Hours of Work, Fatigue and Rest Pauses."

Geological Society, Burlington House, Piccadilly W., 5.30 p.m. 1. Prof. E. J. Garwood and Miss E. Goodyear, "The Lower Carboniferous Succession in the Settle District and along the Line of the Craven Faults." 2. Mr. E. J. Wayland and Dr. A. Morley Davies, "The Miocene of Ceylon."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Professorial Lecture.

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Mr. J. Watt, "Automobile Calculations: Practical Methods for the Designer."

THURSDAY, MAY 11. Chadwick Public Lecture, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Sir Lawrence Weaver, "Rural Re-Settlement and its Relation to Public Health." (Lecture II.)

Royal Institution, Albemarle Street, W., 3 p.m. Prof. F. Keeble, "Plant Sensitiveness." (Lecture I.)

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m. Brig.-Gen. Sir Percy M. Sykes, "Persia, 1916-1919."

Historical Society, 22, Russell Square, W.C., 5 p.m. Miss G. S. Thomson, "The Office of Deputy-Lieutenant and its Historical Significance."

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m.

University of London, at King's College for Women, Campden Hill Road, W., 4.30 p.m. Prof. V. H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture III.) At the Birkbeck College, Bream's Buildings, Fetter Lane, E.C., 5.30 p.m. Prof. Dr. J. C. Shoute "Whorled Phyllotaxis."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Sir E. Rutherford, "Electricity and Matter." (Kelvin Lecture.)

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

FRIDAY, MAY 12..Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W.

Royal Institution, Albemarle Street, W., 9 p.m. Dr. H. H. Dale, "The Search for Specific Remedies."

Anglo-French Society, Scala House, Tottenham Court Road, W., 6.15 p.m. Mr. S. Jamal, "The Conflict in Palestine."

University of London, at the London School of Economics, Houghton Street, W.C., 5 p.m. Dr. P. Giles, "Modern Views of Indo-European Origins." (Lecture I.) At the Birkbeck College, Breame's Buildings, Fetter Lane, E.C., 6 p.m. Dr. E. J. Russell, "Recent Work with regard to the Influence of Soil Conditions on Agriculture." (Lecture I.)

Physical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.

SATURDAY, MAY 13..Royal Institution, Albemarle Street, W., 3 p.m. Prof. O. W. Richardson, "X-Ray and Ultra Violet Spectra." (Lecture I.)

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FRIDAY, MAY 12, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

POSTPONEMENT OF ORDINARY MEETING.

In consequence of the engineering lock-out, Mr. Oswald M. Shepherd, who was to have read a paper on May 17th, on "Recent Developments in Rubber Manufacture, with special reference to Rubber Machinery and the Manufacture of Tyres," has been unable to complete his researches, the results of which he had hoped to bring before the Society. It has, therefore, been found necessary to postpone his paper until next session.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 3rd, 1922 ; MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Howgrave, Walter, Addiscombe, Surrey.
Marshall, Henry, M S.A., Calcutta, India.
Muirhead, Alexander, C.I.E., London.
Pearson, Nels August, Rancagua, Chile.

The following candidates were balloted for and duly elected Fellows of the Society :

Dawson, Frederick Lawrence, Pyapon, Burma.
Risdon, Philip James, London and Hove, Sussex

A paper on "The Production of Titanium Oxide and its Uses as a Paint Material," was read by Mr. Noel Heaton, B.Sc.

The paper and discussion will be published in a subsequent number of the *Journal*.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

FRIDAY, MAY 5th, 1922 ; THE RIGHT HON. VISCOUNT BURNHAM, C.H., Chairman of the Empire Press Union, in the Chair.

A paper on "Imperial Wireless Communication," was read by PROFESSOR W. H. ECCLES, D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal*.

PETER LE NEVE FOSTER PRIZE.

The Prize of £10 and a Silver Medal, offered under the Peter Le Neve Foster Trust, for an Essay on "The Mineral Resources of China," has been awarded by the Council to Mr. C. Y. Wang, Consulting Mining Engineer, of Hankow.

PROCEEDINGS OF THE SOCIETY.

EIGHTEENTH ORDINARY MEETING.
SHAW LECTURE.

WEDNESDAY, MARCH 29TH, 1922.

SIR ROBERT ARMSTRONG-JONES, C.B.E., M.D., F.R.C.P., in the Chair.

The CHAIRMAN, in introducing Sir Thomas Oliver, said that he occupied a very eminent position as the leading consulting physician in the North of England, and he had made valuable contributions to the literature of industrial hygiene, which were known beyond the confines of our own country. His investigations into the deleterious effects of lead in industry had been of the greatest value to employers and employees. They had guided and directed legislation in this and other countries, and his investigations had not only preserved the health of the workers, but had saved many lives by prevention. He was personally indebted to Sir Thomas Oliver for much of the knowledge he possessed in regard to lead poisoning, and the lecturer's contribution upon industrial diseases to Clifford Allbutt's system of medicine, would remain the most reliable classic for reference. His lecture that night was upon the relation of alcohol to industrial efficiency and they were fortunate to have as its exponent such a brilliant scientific and impartial investigator.

ALCOHOL IN RELATION TO INDUSTRIAL HYGIENE AND EFFICIENCY.

By SIR THOMAS OLIVER, M.D., F.R.C.P.

If this country is to regain her pre-war industrial prosperity, it is desirable that

every circumstance which retards her recovery should receive careful consideration. Into the causes which have led to the present unfortunate state of British trade and finance it is not the purpose of this address to enter. What the nation requires, and what is absolutely necessary for the people, are that there shall be a better understanding between capital and labour, that taxation shall be lessened, Governmental control of industries abolished, that men must work so that production be increased, also that old markets must be regained and new markets found. Given these, there must also be industrial efficiency. It is to one aspect of this question that I am invited to draw your attention, viz., to alcohol and industrial efficiency. The subject must be dealt with temperately and, as far as possible, without bias. The increasing use of machinery in production is diminishing the amount of hand labour, and while in one sense machinery lightens labour, in another it creates conditions which not only impose heavy demands upon those who supervise the running of the machinery. but induce a form of fatigue, partly a consequence of the environment in which work is carried on. The fatigue and monotony of modern factory life call for considerable rest of body and mind. Tiredness is a cause of industrial inefficiency and of accidents as well. A craving for excitement and recreation is a sign of a jaded nervous system; so, too, in some intances is a craving for stimulants, whereby the depressing influences of work may be removed. Customs die hard, and yet, on the whole, it may be said that there is less heavy drinking among all classes to-day than there was a few decades ago. Factory work is run on a higher plane and there is not the temptation afforded to men to obtain rum and milk in the early morning on their way to work. To-day the artisan resumes his day's toil after having breakfasted at home, without, on his way to the factory, having the opportunity of purchasing stimulants. The occasions are few where a man who is under the influence of liquor and presenting himself at the factory gate gains admission, or even if he does that, if recognised, would be allowed to work. It is not with this type of case, however, we are immediately concerned. We draw a line between drunkenness and alcoholism. It is, among other things, to the after effects of alcohol as exhibited in the inco-ordinated muscular movements of workmen on the Monday forenoon after a week-end debauch, also to the general question as to whether alcohol does or does not lead to industrial inefficiency that attention is invited. It may at once be said that alcohol should not be allowed to be consumed in a factory. When I was a member of the Dangerous Trades Committee of the Home Office, we found in certain laundries in London that at a certain hour in the forenoon persons from outside were allowed to enter the laundry and retail beer to the women. In all well-conducted laundries this custom has practically ceased.

Any enquiry into the relation of alcohol and industrial hygiene will be incomplete if it leaves out of consideration the home conditions of the worker and the manner in which he spends his leisure hours. There are also the nature of the employment, personal idiosyncracy and hereditary influences to be thought of. It is the effect of the immoderate use of alcohol upon the producing capacity of working men by drinking habits encouraged during their leisure hours, rather than the premature development of disease and its disabling consequences, which merits consideration. There is the opinion, to which Temperance Insurance Offices lend the weight of their statistics, that in a general way, no matter what may be the occupation followed by an alcoholic subject, his life in most instances is shorter than that of a non-alcoholic workman engaged in the same trade. No one questions the harmful effects of the immoderate use of alcohol. On this point there is common agreement, and yet opinion is divided as to whether alcohol never plays a useful part in vital processes. If alcohol is a food, is it a suitable food? If it is a stimulant, conditions may arise in which its use may be called for; on the other hand, if it is such a poison, as some writers would lead us to believe, then it ought to be avoided.

The question of the use and abuse of alcohol might be considered under the following headings, viz.:—The scientific, the ethical, the social and industrial. The ethical aspect of the question hardly comes within the scope of our discussion to-night.

Dealing with the scientific aspect of the question, we ask what is alcohol? In an impure form alcohol has been known and used by men for decades of centuries. Chemists speak of it as ethyl alcohol. It is obtained from the fermentation of sugar, or from starch which has been subjected to

a preliminary ferment action. Wines and beers contain a small percentage of alcohol (2 to 20), while in spirits obtained by distillation from the simpler liquors there may be 30 to 60 per cent. of alcohol, not including certain volatile substances belonging to the alcoholic series. Opinions are divided as to the value of alcohol as a food and the part it plays in the human body in disease. There is little doubt that when concentrated it acts as a local irritant to the lining membrane of the stomach, and after it has been absorbed into the blood, that it has a special predilection for the higher nerve centres. The effects produced by its action upon the brain vary according to the quantity taken, the idiosyncrasy of the individual and the nature of the food which is present in the stomach at the time. Small quantities, taken at a public dinner, for example, may produce only a feeling of well-being and a source of increased confidence in one's powers, mental and physical; slightly larger doses may lead to excitement attended by loss of self-control, as seen in the inco-ordination of muscular movement and of speech, and accompanied by a loss of the sense of responsibility: still larger doses consumed under circumstances other than those described, may throw the individual into a deep sleep, from which with a coated tongue, he awakes nervous and depressed, and if maximum doses have been taken the sleep deepens, the individual passes into a state of unconsciousness, in which he may die through failure of the respiration. It is with alcohol, as with other drugs: all persons do not react towards it in the same way, nor the same individual at different times. We cannot ignore the personal element. As regards the effect of alcohol upon the nervous system, there are the two well-known opinions of physiologists, viz., that alcohol first stimulates and afterwards depresses the nerve cells, and the other view is that there is no primary stimulation at all, but depression from the commencement. Excitement, as evidenced in greater freedom of speech and gesticulation is not necessarily an indication of stimulation of the nerve centres concerned, for it may be the result of a weakened self-restraint over the higher centres through loss of will-power. Cushny alludes to the difficulty of coming to a decision upon this point owing to the fact that even the smallest muscular movement, simple as it may appear, is not so simple after all, but is the result of the combination of motor and inhibitory nerve impulses proceeding from the brain. Thus the apparent self-confidence and the brilliancy of the after-dinner speech of a friend, may not be the result of increased physical strength and stimulation of brain centres, but of the influence of the surroundings in which he finds himself and a consequence of the loss of his usual shyness and nervousness.

Under the influence of alcohol upon the brain nerve force is liberated, but it is not always so well controlled and directed as under normal conditions, the stimulation is fugitive and it is replaced by depression. It is not impossible to get some good work done during the early phase of the stimulation, for even Rivers, who holds strong views upon the subject, admits that after taking alcohol an exceptional amount of work can be performed before the fatigue stage appears. While as a consequence of the imbibition of fairly large doses of alcohol, it is usually the higher and controlling centres of the brain which are first thrown out of gear, and subsequently the motor centres, as evidenced by inco-ordination of muscular movements, yet occasionally as indicating the personal element in the matter, I have known people who got drunk in their legs, who were unable to stand or walk, notwithstanding the fact that their conversational and intellectual powers, so long as they were sitting, seemed to be undisturbed.

In his experiments, Professor Edward Mellanby has gone carefully into the question of the conditions which affect the absorption of alcohol, and he found that in the main, but not always, were the effects produced upon the nervous system proportionate to the amount of alcohol circulating in the blood. Examining the blood of dogs to whom he had given alcohol by the mouth, he found that the maximum of alcohol was present in the blood one hour after the experiment, also, that while the spirit tended gradually to disappear from the blood, there were still traces of alcohol in it 19 hours afterwards. In his opinion, it requires 21 hours for the whole of the alcohol to be removed from the blood, in cases where one dose only of the drug has been administered, also, that if alcohol is administered on the second day, there is found a higher maximum of alcohol in the blood, indicating that a certain amount of accumulation has taken place. The

blood gets rid of the alcohol by a process of oxidation, and it is while this is being accomplished that a certain amount of energy is liberated within the body, which is utilizable. The larger the amount of alcohol present in the liquid consumed, so much the more quickly is the maximum of alcoholic concentration in the blood reached, also symptoms of intoxication produced—and yet there are alcoholic drinks and drinks. Whisky was found to be more rapidly absorbed than stout, even when the percentage of alcohol was the same in the two liquids, a circumstance which suggests that there is something present in stout which retards the absorption of its contained alcohol. It is common experience that alcohol taken on an empty stomach is more likely to be quickly absorbed than when food has just been previously taken. Some foods retard the absorption of alcohol more than others. Milk, probably owing to the fat it contains, particularly delays absorption, so that, to put it in Mellanby's own words, "when rum and milk are taken, the individual has the optimum state of alcoholic intoxication lasting over the maximum length of time." Mellanby was fortunate in securing the services of a man accustomed to the free use of intoxicants, who voluntarily gave himself up to be experimented upon by allowing 5 C.C. of blood to be drawn from the veins of his arms at stated intervals after the ingestion of alcohol. In this man, as in dogs, the alcohol of whisky was found to be rapidly absorbed; in him, too, the maximum alcohol content of the blood attained, as well as the intensity of the intoxication reached, were greater than where the same amount of alcohol was administered in stout. In the case of whisky, the maximum point of concentration of alcohol in the blood occurred about one hour after its ingestion, in the case of stout, not until four hours afterwards. When the alcohol content of the blood begins to decline, the symptoms of intoxication correspondingly fall. Alcohol can be fairly rapidly eliminated from the body on any particular day, but if it has been consumed freely, and the dose is repeated on the following day, the alcohol is not eliminated so rapidly, and therein lie the baneful effects of week-end drinking.

Some of the psychological effects of alcohol have been reported upon by Dodge and Benedict, who carried out experiments in the Carnegie Institute, Washington. They studied the effect of alcohol upon the pulse rate during mental and physical work. It was Sir Lauder Brunton's opinion that alcohol in moderate doses increased the pulse rate. The opposite view was expressed by Sir Victor Horsley and Sturge. All are in a sense right, for alcohol increases or depresses the pulse rate according to the circumstances prevailing at the time. There are few subjects around which there has ranged greater controversy than around alcohol; the facts of experience and experiment do not always agree, nor are the results of experiment always identical, and the experience of medical practice uniform. Regarding the pulse rate in mental and physical work, Dodge and Benedict found that after the ingestion of alcohol there was, in almost every instance a *relative acceleration* of the pulse, meaning by *relative acceleration* a more rapid pulse than what occurs at a corresponding hour of normal days. These physiologists maintain that the increased pulse rate occurs practically in all persons as an effect of alcohol during mental and physical activities. As to the cause of this quickening we need not stop to enquire. It is sufficient to say that for the first half hour there is hardly any appreciable effect: after this, the acceleration goes on increasing for three hours, and then it gradually declines.

Similarly, the intellectual centres, because they are more highly organized and the last to be formed, are readily affected by alcohol. Occasionally, however, it is the lower centres in the brain, those concerned with muscular co-ordination, which are more quickly touched; hence, in alcoholic intoxication the difficulty of standing straight or of walking. Dodge and Benedict, in fact, incline to the view that it is the centres regulating simpler muscular movements which are more severely affected, rather than the intellectual, since even if a man is slightly intoxicated he can yet, under the influence of the will, pull himself together and for a brief period hold mastery over these centres.

Physiology speaks with a somewhat divided voice upon the question whether alcohol increases or diminishes the capacity for work. It does not follow, because of the slightly increased pulse rate which occurs during muscular work and is believed to be a necessary accompaniment of it, that, therefore, any increased pulse

rate consequent upon the ingestion of alcohol means greater capacity for doing work, and this statement is made, notwithstanding the fact of the extra work obtained by the action of small doses of alcohol upon excised muscles and the recuperation of a failing heart in perfusion experiments. Work carried on at an even pace, under normal conditions, may be unattended by any such rise of the pulse rate as to call for special comment, for, as Prof. H. M. Smith has experimentally demonstrated, a man's muscular metabolism during a long walk may be increased 2½ times without his pulse rate being increased at all. We get little assistance, therefore, from a study of quickening of the beat of the heart and its relation to muscular activity.

A much more disputational problem is whether alcohol is a food. What is a food? Is it a substance which merely sustains and nourishes the body, and is capable of being assimilated by it; is it something which, under the influence of digestion, is only capable of repairing the wear and tear of the tissues, or does it also include other material which, without becoming incorporated, can supply energy, and by so doing thus spare the tissues? Alcohol is not assimilated, and it does not enter into the composition of the tissues, and on these terms, therefore, it cannot be regarded as a food, but if it is capable in the body of supplying energy, and of thus saving the tissues from breaking up in order to supply energy, then it is a food, but of an indirect kind, for when alcohol has been absorbed only about 5 per cent. of it is eliminated from the body as such, the remaining 95 per cent. being retained in the body to undergo combustion and be made use of. So slowly is the oxidation carried out that, as we have seen, traces of alcohol are still in the blood 24 hours after it has been taken. When alcohol is undergoing combustion in the body, it gives up energy and thus becomes, technically speaking, a food; but while we accept this as a physiological fact, there are few of us who would say that it is a desirable food under all circumstances, and one to be recommended. It may save the carbohydrate in our tissues, also the fat, so that these remain as reserves of energy; but alcohol is foreign to the body; it can never become part of the tissues or stored up in them so as to be called upon to meet requirements in the same way as carbohydrates. Physiologists have found an increase of fat in animals to whom alcohol had been given, and the same thing has occurred in man. A few years ago, probably more than in these days, men who worked as labourers in the London docks used to consume large quantities of stout. Most of them were well nourished, and were capable of doing a large amount of hard physical work, but this circumstance was not altogether owing to the presence of alcohol in the stout, but was probably and more likely the result of the large amount of carbohydrate the liquid contained. These men were not only paying extravagantly for the energy they required, since more energy could have been obtained and a larger reserve secured from selected foods, but they were running the risk of injuring some of their internal organs by excessive stimulation of their eliminating functions.

Into the personal, familial and social aspects of this question I do not propose to enter, for the personal and social effects of the abuse of alcohol are known to all of us.

I have incidentally introduced the question of "alcohol a food," because it is an opinion expressed by some working men that alcohol supplies energy, an opinion which, notwithstanding what I have just said, must be received with some qualification, since we must distinguish between the immediate and remote calls upon the energy producing activities of spirit. Alcohol might supply energy for a sprint, but would it evolve the energy required for a long distance race? The stimulating but fleeting effects of alcohol are shown in the "doping" of greyhounds in coursing matches. Owners of racing dogs have told me that it is not an uncommon practice to give dogs light alcoholic stimulants, e.g., champagne, before a competition, but the owners have to know pretty accurately the time the start will take place so that the requisite amount of dope may be given to the animal in order that the stimulating effects may come into operation at the particular period it is required, for, should anything occur to delay the starting of the race, the exciting effects of the dope will have passed away, and these will be followed by a langour whereby the animal's efforts result in failure. The experience which I have just given may be crude, but it cannot altogether be ignored when taken in conjunction with other facts. No boxer or football player ever trains upon

alcohol. It is, in fact, the one thing to be avoided. The trainer of the Newcastle United League Football Club has had 40 years' experience of footballers, and he tells me that few players are of any real value to their club after 10 to 15 years' service, but there are men in his club, as probably in other clubs, who at the age of 40 are still playing an excellent game, and the majority of these men are total abstainers. The trainer does not say that the man who takes a glass of beer occasionally is not as good a football player as an abstainer, but, taking two men who began as professionals at the same age, the abstainer will probably be found in better physical condition at the end of 15 years than his confrere who has used alcohol immoderately. Trainers of footballers, who often become abstainers themselves, so as to be an example, discourage, as far as possible, the use of stimulants, for they have observed that after 20 minutes' play in a match, the men who take alcohol rather freely cannot compete in endurance with the others.

Science has been invited to give expression of her experience in regard to the relationship of alcohol and muscular work. Rivers, in his monograph, tells how Lombard, by means of the ergograph, found that alcohol primarily increased the amount of muscular work done, and that this continued for a short period. Rossi similarly observed a slight increase, followed by a fall. Frey, on the other hand, found a primary diminution of work done, but if alcohol was administered after fatigue had set in, that it had a decidedly beneficial effect. According to Frey, alcohol has a peculiarly double effect: (1) it acts injuriously upon the nervous system and diminishes work; (2) it acts as a muscle food and is, therefore, helpful. Other physiologists have found that while alcohol has no special influence upon healthy muscular fibre, it is capable of whipping up tired muscle so that it becomes capable of doing extra work, but the period during which this continues is short, it is followed by a fall and the decline is always to below the normal.

In a matter of the serious importance we are discussing to-night I am of the opinion that the results of physiological experimentation upon animals, however interesting and valuable they may be, must be considered in the light of, and along with the facts of, human experience. It may, therefore, be not out of place if I mention the experiments carried out by two American physiologists, Atwater and Benedict, upon themselves. We have dealt mainly with experiments upon animals, let us take man himself. Atwater and Benedict allowed themselves to be shut up in closed chambers, which might be spoken of as large calorimeters. The heat produced was regarded as a measure of the energy obtained from the foods supplied. After a few days' experimentation with food, alcohol was substituted, when it was found that the heat produced was not influenced by the change of diet. The effect of alcohol upon work was then studied. Part of the experiment was that the two physiologists had to turn a dynamo which fed an electric lamp, the heat produced being a measure of the work accomplished. The amount of work remained the same, whether food, or alcohol, was the diet. The results obtained aroused a good deal of interest at the time, and gave rise to considerable discussion, especially in France, a wine producing country. It was pointed out, however, by Rübner that production of heat is not an end in itself, but an incident of life, and that the value of food rests not alone upon the heat which is liberated, but upon the extent to which energy set free can be made use of in vital processes. Physiologically speaking, alcohol is a food, but as Atwater, who was the subject of the experiment just mentioned, reminds us it is a bad food and an undesirable one, and to these words may be added those of other physiologists, that while alcohol in small quantities can undergo combustion in the body, in larger doses it does so to the injury of the body itself.

Many of us are familiar with Dr. Vernon's work upon this subject. Professor Edgar L. Collis, too, in "The Health of the Industrial Worker," has written a helpful and instructive paper upon "Alcohol and Work," but the question bristles with difficulties owing to the conflict of opinions and the absence of uniformity in the results of experimental physiology. It is the subject of alcohol and industrial efficiency which particularly calls for our consideration to-night, and it is upon the relationship of these two that I find it almost impossible to obtain information from managers of large works, both in this country and the United States of America. I can get plenty of opinions, but I can get few details of experience, for data have not been collated. The present attitude of the public mind

towards alcohol is an illustration of the changing circumstances of time, and of the march of an increasing number of the people towards sobriety. By improving the conditions of labour and making trades more healthful, industrial hygiene has encouraged self-respect among the work people and by widening their outlook, has caused them to take a greater interest in movements which tend to make life fuller and occupation freer from sickness and accident. The trend has been in the direction of the preservation of the working classes.

So far as industry and alcohol are concerned, there are certain occupations which, if they do not predispose, certainly encourage persons employed in them to take alcohol to excess. This remark applies particularly to persons engaged in the manufacture and sale of alcohol. Previous to the war, it was found in Munich that at the age of 20, the life of a person engaged in brewing beer was 22 to 38 years, while that of the average individual otherwise employed was 42 years. In pre-war England the mean expectation of life at 25 was 36.1 years, and in publicans it was 31.3 years. In Prussia, taking all the alcohol industries together, the expectation of life of individuals at 25 years of age was, for the average male population, 32.08 years, and that of those engaged in the alcohol trades 26.23 years.

Here the kind of work is responsible for the shortened working period of a man's life. There are, however, certain trades and conditions under which labour is carried on which create a desire for stimulants. Too long hours, working overtime and Sunday labour, also over-speeding, by producing fatigue, create a desire for stimulants. Hard physical labour, such as the puddling of iron and work carried on in overheated atmospheres, have a similar tendency. In some of the large glass works on the Continent, I have seen the men who were working at the furnaces consume in the factory large quantities of alcoholic drinks to replace the liquid lost by perspiration. Men employed in glass works across the Border drink large quantities of beer. The practice of beer drinking was introduced into Scotland, Professor Glaister informs me, by men from England when they went North to establish the industry, and while in these works for many years there is no difference in the output or in the physical fitness of the two sets of men, drinkers and abstainers, yet, at the end of 15 or 20 years, the alcoholic workmen cannot compete with the men who abstain—at any rate, when at work. This circumstance has been recognised by the men themselves, with the result that workmen who were in the habit of consuming beer in the factory, have taken to the "oatmeal and water" drink of their comrades and with satisfactory results.

Dusty occupations by causing dryness of the mouth and throat also encourage intemperance. There is one trade in particular which is apt to cause the men to become intemperate ; I refer to the making of mill-stones for the grinding of cereals, etc. Mill-stone building is a special trade and is carried on in few places. In chipping the hard "buhr" stone fine dust is given off and this is inhaled. I have visited the works on the banks of the Thames and at Ferté Sous-Jouarre in France. The habits of the workmen are the same in both places. The majority of them drink to excess. After they have followed the occupation for a few years they suffer from hemorrhages from the lungs and have but a short life thereafter, many of them being carried off before the age of 40. I was much impressed at the time of my visit by the death at a comparatively early age of these millstone builders, both in London and in France, so that in order to refresh my memory and to be accurate in regard to facts, I recently wrote to the town's doctor at Ferté-sous-Jouarre for information, and he reminds me that while all the workmen are more or less exposed to dust, it is the men who build up the mill-stones by putting the wedge-shaped pieces of stone together who suffer most, owing to the fact that their work is more fatiguing, that they receive the largest wages and drink most. Many of these men when the value of the franc was high could earn 600 to 800 francs per month, and they drank from 7-8 litres (1½ gallons) of red wine daily. There is a history of alcoholism in 90 per cent. of those who die from tuberculosis of the lungs. Men are attracted to the occupation because only a short apprenticeship is required and they are soon in receipt of large wages, which they unwisely spend in drink. Some of these men work for 19 days and during that period they make 400 francs ; they take their wages and drink till their money is gone and then resume work again. It is the men who drink largely who die young.

For years there have hovered round this question of the abuse of alcohol by working men, the incidents of accidents in factories, irregular time-keeping, diminished output and imperfect workmanship. It is pointed out by nearly every writer upon the subject that the largest number of accidents happens in factories and shipyards on Monday, and that this is largely the result of alcoholic indulgence on the part of the working man at the week-end. The practice of week-end drinking is not confined to one country. When we examine the 25,295 accidents which occurred in the high building trade in Berlin a few years before the war, we find that most of the accidents occurred on Monday, viz., 18.7 per cent., as against 15.6 on Tuesday, and 16.6 on Friday, and when we add to these the statistics of German Trade Union Associations, with a membership of 400,000, these also show that the number of accidents declined as the following days succeeded each other, Tuesday, Saturday, Friday, Wednesday, Thursday, Monday and Sunday—the largest number of accidents on Tuesday being explained by the circumstance that the bulk of the men did not return to work until Tuesday.

Mr. H. J. Wilson, H.M. Superintendent Inspector of Factories, dealing with this subject shortly before the war, has no doubt whatever as to Monday being nearly in every instance the accident producer, and next to it is Tuesday. Taking accidents in shipyards, he supplies the following percentages :—

Monday,	24.2 per cent.
Tuesday,	19.0 ,,
Wednesday,	15.1 ,,
Thursday,	15.0 ,,
Friday,	15.2 ,,
Saturday,	11.1 ,,

At this date the men were working 9¾ hours daily, except on Saturday, when the hours were 5½.

The general consensus of opinion, on the whole, is that Monday is the day of the week on which the largest number of accidents occurs. In the Zurich Building Trades, 1900-1906, the accident rate on Monday was 22.1 per cent. as against the average of 15.7 per cent. for other days—that is 3 to 2, and as regards accidents generally to abstainers and non-abstainers in the iron and steel works at Volklingen there were 8 per 1,000 in abstainers and 12 in non-abstainers—that is in the ratio 2 to 3—whereas the Leipsig Benefit Society found only one accident in abstaining workmen to three among men who were alcoholic.

Since May, 1914, when the public-houses have not been opened until 10 a.m., there is a feeling that there have been fewer accidents on Monday, but the conditions under which, during and since the war, labour has been carried on, do not enable us to speak definitely in regard to this. On the Clyde there was no evidence that drinking had increased during the war. It was practically the same men who frequented the public-houses then as before the war. There was evidence, however, that a number of small bottles of whisky had been consumed off the premises especially by men engaged on the night shift; but, after all, the practice was confined to few men since in one shipyard employing 10,000 men, only three men on one night were found partially intoxicated and had to be expelled from the works.

Irregular time-keeping, and many employers consider this equally important as the question of accidents, is largely the result of drinking, but this occurs also among total abstainers. Lost time is met with in some trades more than in others, *e.g.*, among rivetters, caulkers, platers and riggers and to a less extent in engineers. In shipyards it occurs more frequently in men employed on outdoor work and exposed to the weather. The details of irregular time-keeping require to be sifted, for the mere mention of lost time and of the number of men involved is not enough. One circumstance, for example, which causes irregular time-keeping is group working; riveters work in squads so that if one man fails to turn up at 7.30 a.m. the squad cannot commence work. Four or five men, therefore, lose a morning's work, or it may be a whole day's. Riveting is hard work and the men are exposed to the inclemency of the weather. There are, therefore, several inducements for the men to take a day off, especially as the pay is large and it enables them to do so. For some reason, riveting and plating are not attractive occupations, and as a result there is always a shortage of this class of workmen, a circumstance which causes the wages to be high, and as the men know that there are few other workmen to take their places, there is no stimulus to them to put forth their best exertion.

"Lost time" in industry is a serious matter and one which can only be restituted by the working men themselves. That it can be improved has been shown by the action taken in some large factories of which the following may be mentioned:—Messrs. Creed and Co., engineers, at Croydon, three years before the war were employing 150 men, and in consequence of lost time they made total abstinence a condition of employment. The average lost time in the engineering trades generally before the war was about 10 per cent., but in Messrs. Creed's works it fell to half of one per cent., and while, during the war in the average engineering shop, "lost time" rose to 15 per cent., in Creed and Company's works it was from 1 to 2 per cent., in 1917, and 5 per cent. in 1918.

There is more irregular time-keeping in the shipbuilding industry than in such trades as engineering and iron and steel making. Several circumstances may contribute to this. It may be that exposure to severe weather in winter with rain and high winds has something to do with the greater loss of time. It is hardly right to have men working in their wet clothes and catching cold through hanging about afterwards, for this circumstance of itself tempts the workman to take alcohol.

One large firm on the Clyde took a vote from the men as to whether in their opinion there should be further restrictions placed upon the sale of alcohol. Mr. H. J. Wilson has sent me the following figures of those voting in favour of restriction:—

	per cent.
(1) Are you in favour of total prohibition?	31
(2) Are you in favour of leaving matters as they are	44
(3) Are you in favour of reducing the hours to from 12 noon till 2 p.m. and 7 to 9 p.m., and on Saturdays 6 to 10 p.m.?	11
(4) Are you in favour of reducing the hours from 7 to 9 p.m. on weekdays and on Saturdays 6 to 10 p.m.	4
(5) Are you in favour of leaving the hours as they are, but for the sale of beer only?	10

Out of 2,500 men two-thirds voted.

Following up my enquiry it seemed to me that it would be helpful if I could ascertain the opinions of large shipping firms in regard to the part which alcohol plays in the life and work of the British seaman. I accordingly wrote to Sir William Noble, a well-known North of England shipowner, who is interested in these problems and who as Chairman of Societies connected with shipping has been able through the Manager of the Shipping Federation to obtain for me the information I desired. I asked Sir William Noble whether a few years ago it was a common event for ships to leave ports in this country with some of the sailors not in quite the best state of body and mind for the voyage as a consequence of drinking, whether his own office or associations had any data regarding inefficiency of service on the part of seamen from alcohol, also after a drunken bout, as to how many days were required before the affected men could undertake full work? Sir William Noble, in his reply, stated that there was less trouble now than in former days. It is still, however, an unfortunate fact that men on going to sea join the ship under the influence of drink. Two or three days might elapse ere the men were quite themselves again and fit to take up their duties. Unfortunately, however, the difficulty arises on each occasion the ship reaches port and when the men ask for money on account of their wages.

Mr. Havelock Wilson, writing to Sir William Noble and acknowledging the receipt of a copy of my letter which had been forwarded to him, says: In the old sailing ship days such cases did happen, but in the days of steamships it is very rarely that sailors go on voyage with their health affected by drinking. Such cases are more often to be found among firemen. My experience of many years is that the men of the mercantile marine have improved very much with regard to drinking habits. I do not mean to say that there are no cases where crews proceed on voyages in a drunken condition, but taking them generally I think they will compare favourably with any other body of men.

Mr. Cuthbert Laws, General Manager of the Shipping Federation, London, very kindly took up the matter and wrote to Technical Advisory Committees and to several of the large shipping offices of this country, asking them to give an expression of their opinion upon the questions raised in my letter, and which for simplicity he classified thus:—

(1) Was it a common occurrence a few years ago for ships to leave ports—

(a) in this country, and
(b) abroad,
with seamen either wholly or partially incapacitated as the result of drink ?

(2) How does the present position compare with the pre-war position ?

(3) Can you give any estimate of the amount of time lost by seamen in consequence of drink and the degree to which the efficiency of their service has been impaired from this cause ?

(4) Has it been your experience that total abstainers do better work and give more efficient service than men who drink freely—
(a) during the period when men are sober ?
(b) taking the service as a whole ?

(5) Have you any general observations to offer on the subject of alcohol in relation to employment at sea ?

The questions which the General Manager of the Shipping Federation drew out, and to whom I take this opportunity of tendering my thanks, quite cover the ground I had in view. Forty-eight shipping firms replied to Mr. Cuthbert Law's questions, but not all of them directly and to the point.

In regard to No. 1 (a) 43 replied yes, and to (b) 41 gave an affirmative answer.

In regard to question (2) 38 stated that the position was better, 4 that there was no improvement, and 1 that things were worse now than formerly. As to question (3), it was affirmed by 33 that time was lost, 15 stating that this was equal to one day or part of a day, 6-8 hours, and five that it was one to two days or even more. Question (4), which asked whether abstainers did better work was answered thus: (a) 17 yes; 18, however, stated that if the work done by men who took alcohol was not better, it was certainly as good as that done by abstainers, while a few thought that the work was better; and in regard to (b) 25 replied "yes" and 10 "no."

Some of the remarks made and the suggestions offered by shipping firms are interesting and call for notice. There is the opinion that as a class seamen are well behaved and compare favourably with men in other occupations. Opinions are divided as to whether alcoholic drinks should be taken to sea and sold by the captain of the ship to the men, for there is a feeling that it is the deprivation of stimulants during a voyage which is partly responsible for the men breaking loose when they reach a seaport, and then even in port, particularly abroad, it would be safer and better for the men if stimulants were procurable on board of ship instead of in the public-houses. Against the sale of alcohol on board ship, either during a voyage or in port, many owners are of the opinion that alcohol should be served out as a medicine and only under necessitous circumstances. There is not the least doubt that men who in port exceed the limits in regard to the use of alcohol, once the effect of a debauch has passed away, are good workers and are in no way inferior to abstainers. But it is just the debauch in port which not only causes loss of time, but may interfere with the safety of a ship—so much is this the case that some of the shipping firms maintain that no man should be allowed to proceed upon a voyage who is under the influence of drink. Those who know that it is these men who do not turn up until almost the last moment before a ship sails, can appreciate the difficulty of giving effect to this recommendation. As a consequence of allowing firemen to proceed to sea who have been drinking too freely, considerable damage has occasionally been done to the boilers of the ships, and as a result of seamen not arriving in time to sail with the ship, coloured labour has frequently had to be resorted to instead. It is an open question whether the stopping of advanced pay to seamen would diminish the amount of drinking when a port is reached. Of all occupations that of going to sea is one particularly in which total abstinence has its advantages, for whether abstainers are better workers or not, they at any rate are more reliable under all circumstances. It is worth considering whether stoppage of advanced pay, not only to seamen, but to men employed in other occupations, would diminish drinking. There is not the least doubt, as a large building contractor on Tyneside writes to me, that previous to the war alcohol was the cause of much lost time through week-end drinking. Since the war this has been less noticeable owing to there being fewer opportunities of obtaining alcohol, and that the younger men are seeking relaxation in other directions, such as sports and entertainments. In the building trade it is difficult to ascertain the amount of industrial inefficiency caused by alcohol since no reliable data are available and many of the workmen are only casually employed. From general

observation the loss to the workman in days off through alcoholism 15 to 20 years ago could be estimated at one day per week per man ; immediately previous to the war this was considerably less, and since the war the loss has been almost negligible. The loss of time through sickness is to the abstaining workman about half of that lost by the alcoholic. I had asked this contractor how far he thought what is called "subbing," that is, payment of part of the wages to the men in the middle of the week, was a real help to the men themselves, what was the type of the men who asked for it and whether "subbing" had any influence upon the character of the work done by the men in the latter half of the week ? In the building trade "subbing" is largely a personal matter; it is made use of mainly by the unskilled men. It is asked for regularly by men who, having earned the wages, claim the right to a large part of them, while occasionally the request has to be made by men who have been out of employment, and who with their families are in need of sustenance. Men, as a rule, do not lose a day's work after "subbing," although in a few instances it is clear from the manner in which the work is done that they are not quite clear from the effects of alcohol.

Another large contractor states that conditions since the war have materially changed for the better. This contractor has always been opposed to the practice of giving "sub" to the men unless in exceptional cases, such as a man having been out of employment for some time, but when labour is difficult to obtain, men frequently refuse to work for a firm which does not give the mid-weekly pay. His opinion is that men who "sub" regularly are not so efficient in their work, a circumstance for which he thinks alcohol is to some extent responsible.

I am informed by one of the under managers of a large shipyard on Tyneside, and who has had considerable experience of the Clyde, that many riveters employed there do not commence work until Wednesday morning, when they ask to be supplied with 1000 rivets. These men work their hardest for the next 3½ days, and the work is by no means light. Since several of the men have already consumed the wages of the previous week, they are obliged to be paid their wages wholly or part in advance, on the understanding that they will give adequate service in return. This system is called "flogging dead horses." Unfortunately, when Saturday afternoon comes, many of the men resume drinking, with again lost days of work in the following week, and as a result of hard work and hard drinking continued over a lengthened period, these men, after 15 to 20 years, are physically speaking done.

To bring this lecture to a close we will ask the question what benefits do working men expect to get from alcohol, and what do physiology and industrial experience promise them ? It is generally admitted that the sub-division of labour and the multiplication of machinery have made present-day work monotonous and in certain quarters there is a feeling that alcohol by paralysing the critical faculty blunts the senses to the influence of monotony. The remedy, therefore, is not to denounce alcohol solely, but to widen the interests of the working classes by making work more congenial, if such is possible. While admitting that monotony of work may be a cause of drinking, if this were the serious cause which has been advanced we would expect to find drinking more prevalent among indoor workers shut up all day amidst the noise of running machinery in textile factories, whereas if drinking is not more prevalent, certainly its effects are more apparent in men engaged in the harder trades in which they are exposed to high temperatures or to the severity of the weather.

Although I have dealt at considerable length with it, the question of alcohol being a food hardly concerns us, for while physiological experiment shows that it can be ranked as such, it is only indirectly by sparing tissue, to the building up of which it cannot contribute. No one would recommend it as a food on account of its costliness; besides, two ounces of pure alcohol is stated to be the limit which can be burnt up in the body without harm in a day. It is impossible to say how long it takes for alcohol consumed in larger quantities than I have mentioned to produce structural changes in the body. The effects are functional at first and are primarily seen in the loss of co-ordination of nerve centres in the brain. It is in consequence of frequently repeated functional derangement of brain and liver without sufficiently long intervals of abstinence for recovery to take place, that week-end drinking, with all its

objections, is less harmful than constant sipping. And yet, so far as the man who uses alcohol sparingly and in moderation is concerned, neither experience nor physiology shows that he is an inferior workman to the abstainer Although the question is mainly a personal one, in the Western Hemisphere it is being made a race problem. A few years ago, had I asked myself whether abstaining nations or peoples had done more work and better, and had contributed in larger measure to the cause of civilization than those using alcohol, I should have felt inclined to answer *No*; to-day the answer must be withheld for a large, vigorous and prosperous nation has taken upon itself the task of making its people sober. An experiment on a gigantic scale is being carried out by the United States, and the civilised world looks on, awaiting with patience the results, for by many persons it has been held that those nations have been the most progressive whose people have been proteid consumers, largely of meat, and who have not denied themselves the luxury of alcohol. It cannot be said of the Mohammedan races of Asia and of Eastern Europe, for example, that total abstinence has raised them to a higher plane of civilisation, given them a prominent place in the industries of the world or conferred upon them those practical qualities so characteristic of the men of the west.

The drinking habits of a nation change. It is so in this country, and many thoughtful members of the industrial classes are asking for guidance in regard to the subject. Whether alcohol is taken by working men to-day to minimize the effects of monotony and dispel the sense of fatigue, or not, it is evident that drink is consumed less for the sake of conviviality than it was years ago. Even admitting that it is taken to dispel the sense of fatigue, it is doubtful whether fatigue is really dispelled, for it may be as Professor Cathcart and many of us believe, that the sensory centres in the brain are simply benumbed so as to be less influenced by the conditions which create fatigue. It is in consequence of this peculiarly paralysing action upon the higher and psychical centres in the brain that alcohol has ceased to be considered a stimulant and is now regarded as a depressant. Alcohol does not increase the resistance of the body to disease; too often it paves the way to such a disease, for example, as tuberculosis. When taken to the point of interfering with the operation of co-ordinating nerve centres in the brain, alcohol tends to impair efficiency, intellectual and physical, so that no man who has important work to do is acting in the best interest of the work, nor is he doing the best for himself, by undertaking work upon alcohol.

DISCUSSION.

The CHAIRMAN said he should like to congratulate the Council of the Royal Society of Arts on having such a paper read just at a time when it was very difficult for men to get work, and when it was most necessary to get the maximum output with the minimum effort. Those present had listened with a very great deal of instruction and pleasure to the paper, and had got the very thing they wanted in a paper upon such a subject, and that was, facts. The arithmetical argument appealed to other people, as well as to themselves. The learned physiologist said that this question of alcohol might be dealt with from four aspects, but he was going to leave out the ethical. He himself found it most difficult to keep his temper when discussing the effect of alcohol, because of all substances in nature, it was the one which had the most far reaching consequences. Human energy was too valuable to be mis-used or wasted: in the vast field of human labour it needed careful supervision, and should be fostered in the most special way possible. The first thing for anyone to do if he wanted to keep well, and do the best work, was to guard against the enemies of the body, and he maintained that there was one enemy in particular which could so delude the reason as to give, when taken to excess, the feeling of increased happiness, well-being and comfort, and it was the effect of the excess in regard to this enemy that was the subject of the paper they had just heard. Alcohol came from a bad family, being allied to naphtha, benzine, kerosine and petrol, which nobody would think of drinking. They had abundant proof of the effects of alcohol upon living tissues, and he could confirm that in his experience, which was very extensive amongst working people and the industrial classes. If a plant was watered with alcohol, in a very diluted degree, it soon curled up, withered and died. Creatures in the lower scale of life, like tadpoles, died at once when dropped into much diluted alcoholic solutions, and the experiments carried out on the Canadian trapper and hunter, Alexis St. Martin, who went to live with Dr. Beaumont, the physiologist, proved most conclusively that alcohol paralysed the nerves of sensibility and irritated and inflamed the gastric mucous membrane. Alexis had

the front part of his body wall blown off, leaving a little window which permitted the physiologist to look into the stomach during digestion, and see what went on when alcohol was administered. The liver got hard, and, like a carter's boot, "hob-nailed," and the brain shared the same fate when drinking was habitual and long continued. As Sir Thomas Oliver had said, the highest tissue was first affected, because it was the last formed, the least organised, and the least fixed, and the mental effects of long continued alcoholic excess were (1) a difficulty in fixing and concentrating the attention; (2) an impairment of memory, and (3) a perverted, deflected and oblique moral sense. The memory, reason and judgment, being the highest faculties of man, were affected. A man who indulged a long time in alcohol, was on the borderland of insanity; and when he was the Medical Officer at Claybury, 20 per cent. of the men and 10 per cent. of the women patients were certified to be insane because of drink, many of these being high class workers. The insurance companies knew this, and realised that the person who drank was not a good "risk"; that 51 non-abstainers to one abstainer died between 21 and 30 years of age, or, in other words, the deaths were 50 times greater. Also, at 20 years of age, a temperate person had the expectation of living to sixty-five and one-fifth years, while the non-abstainer would only live to 47½ years. Alcohol deserved the name of deceiver. It made a man think he was happy, and yet he became more wretched. It soothed pain because it paralysed the nerves; it relieved hunger because it soothed the appetite; it removed the feeling of cold because it dilated the vessels of the skin, and so gave a false sensation of warmth, whilst in reality it lowered the body temperature. The war gave us an opportunity of controlling the consumption of alcohol, and for this first movement in restriction and reconstruction, we owed special thanks to the trade unions, which called the attention of the Government of the day to the delay in transport, great slackening in making munitions, and to ill-health owing to excessive drinking amongst the workers. Thanks to the Board of Control (Liquor Traffic), and to Lord D'Abernon in particular, special restrictions were made after a request had been presented by the local authority, and by means of these a vast change occurred, so that the whole country practically came under restricted orders, but the trade unions, which were originally mainly responsible for establishing restrictions, later clamoured loudly for more drink, and so the Licensing Act of 1921 was passed, extending the hours of sale, and permitting the Licensing Justices to exercise a discretion, and, as a result of this, they had been bombarded with petitions to extend those hours, and counter petitions not to do so. The result of Lord D'Abernon's administration was less consumption of alcohol—a decline of 18 per cent. in 1918 compared with 1917, or of 60 per cent. as compared with pre-war consumption in 1913. Another result was less crime; crimes of violence in 1919 were 71 per cent. less than in 1913. Juvenile crime in 1918 numbered 27,787 instances, while in 1913 it was just under 150,000. In addition there was more work got through, there was greater order in the streets, and on railway platforms, more money was placed in the Savings Bank, and there was greater contentment. He was informed soon after the Welsh Sunday Closing Bill became law, that in the slate quarry districts the men then went to work on Mondays. The effect of alcohol was experimentally ascertained by very careful observations made (1) by testing the memory, and (2) by recording the influence of alcohol on manual work and neuro-muscular co-ordination, and much information was gained in regard to the effects of alcohol taken concentrated or diluted, and also without food and with meals. The method adopted by one observer, Dr. Vernon, was with typewriting, when speed after alcohol was delayed, and lessened accuracy was displayed, the quality and the quantity of the work being definitely affected. Another method was the so-called "target method," which meant pricking a certain number of marked spots at a given distance in a given time, which showed that, after alcohol, three times the number of errors were made as compared to those made when not taking alcohol. The scientific committee appointed by Lord D'Abernon furnished the Board of Control (Liquor Traffic) with a report that should be in the hands of every person interested in temperance, and especially of those who were interested in increased production in industrial enterprises. The results of Prohibition in America were not being fairly dealt with in the Press. There was so much propaganda in order to influence Great Britain, that the Press in America did not give the present legislation a fair deal. Those results were diminution of industrial accidents, better time kept, better home conditions, better health, fewer admissions to hospital, the acquisition of the saving habit, fewer bad debts to tradesmen, homes were purchased, luxuries formerly unknown to the family in the shape of clothes, food and holidays, were obtainable under the present circumstances, there was less destitution, greater content and happiness, and *increased laundry bills*, indicating that there was a greater feeling of self respect.

MR. W. MCADAM ECCLES, M.S., F.R.C.S., remarked that, like the rest of those present, he had been intensely interested in Sir Thomas Oliver's paper, coming, as it did, from such a centre as Newcastle-on-Tyne, which, as they all knew, was a very hive of industry. There were one or two points he should like to allude to in connection with his paper, rather in the way of elaboration, and not of criticism. Sir

Thomas had alluded to the point of team work and had said that, if one of the teams was incapacitated, or for one reason or the other did not put in an appearance, there was a failure in efficiency, because the whole of that team was thrown out of gear. The speaker said he did not know, of course, the ins and outs of shipbuilding, but he did know what it meant in the team work in his own profession of medicine, and he knew that if there were in a team one or two who were not up to efficiency, particularly through alcohol taken in the middle of the day, it was a very serious matter to the smooth running of that team's work. Then, in regard to accidents in factories, there was one matter which he did not think Sir Thomas had alluded to—it was one of exceedingly grave import—and that was that the consumption of alcohol—not necessarily when the consumption was sufficient to make a man a drunkard—was apt to have the effect of dulling the sense of danger, and, further, these men were very apt indeed to disregard accident warnings. In fact, it was well known that when the first warning was put up on Monday morning, it was far more apt to be disregarded than if the warning occurred later in the week. Then there was the fact that the alcoholic worker—and, again, he was not alluding necessarily to those who were habitually under the influence of alcohol—was a danger to his fellow workers, a very important point. Passing on to the point of health, Sir Thomas had said that alcohol was the direct cause of disease. That they all knew, and while alcohol was an indirect cause of disease, the inefficiency due to alcohol was the result of its preventing the natural functions of the body being carried out to their best effect, particularly in connection with digestion, and directly there was a failure of proper digestion, they got inefficiency in the workers, who could not then put out the utmost of their strength. Sir Thomas alluded to the question of fatigue. He himself was always prone to put it in this way, that alcohol was a narcotic, and, therefore, fatigue was covered but not removed, or, to put it a little more scientifically, fatigue was due to waste products in the muscles and other parts of the body, or what might be called—and he thought Sir Thomas would agree—poisoning, and until this poison could get out of the body, it interfered with labour. Alcohol dulled the sense of fatigue, but it left toxin in the body, and still further time was required to eliminate the fatigue products. This was a very serious question in the matter of efficiency. The last point he would allude to was this, that if alcohol was really a disadvantage to the industrial workers and to the efficiency of our nation, which was was absolutely necessary at the present time, these facts concerning alcohol should be kept before our workers continually.

Mr. George B. Wilson (Political and Literary Secretary, United Kingdom Alliance), said he had been very pleased to hear what Sir Thomas Oliver had said about America, and he certainly thought that a great duty devolved upon this nation in keeping an open mind on the question of America. He thought that Sir Thomas would agree that they could not expect to see the general results of prohibition in America, whatever they might be, exemplified conclusively for a number of years, and he should be very much obliged if Sir Thomas would tell them what were the directions in which they must look for evidence which would be useful for this nation. He remembered talking a couple of years ago to Professor Irving Fisher, when he was over in the States, and he made some very strong statements about the effects on the ground of efficiency that the coming prohibition would bring about, and he further said that he would be very much surprised if prohibition did not result in an increase in America of something like 30 per cent. of the general efficiency of the nation. He said he was pretty certain it would be 20 per cent., but he was prepared to stake his reputation on 10 per cent. When they thought of America with its unlimited natural sources, its immense man power, and the other great advantages, which it had in contrast with us, and especially when we considered the loss of so many of the finest of our young men, we could see the possibility of America beating us in the industrial race, and he thought that our leaders of industry, both employers and leaders of trade unions, had not sufficiently realised the importance of asking themselves this question : "Supposing America is going to gain a ten per cent. increase of efficiency as the result of prohibition, can we afford to give her such a start in this age of industrial competition ?" It seemed to him that the answer to that question ought to determine the attitude of our own nation on this great question of alcohol, and if the evidence that had been brought forward that evening was, as they believed it to be, thoroughly sound, it seemed to him that there could be only one answer to the question. If this non-alcoholic law put America on far better terms than ourselves in the industrial struggle, this nation must at any rate, seriously consider whether the American action was not an action which could be followed in this country. Therefore, it seemed to him a very unfortunate thing that the issues were not being fairly put to this country, which was not being allowed to consider this matter as a great social and industrial experiment, and he hoped that all those who could get into the Press, when so many were excluded, would take the opportunities which were open to them, from the prominent positions they held, of impressing on the people of this country the need of keeping an open mind on this matter. When

they had got the whole of the evidence before them, let them strike the balance fairly one side or the other. Only in that way could our nation come to a right decision.

Sir George Hunter, K.B.E., said he was deeply interested in this question, and particularly in Sir Thomas Oliver's observations. He hesitated to take part in the discussion, because he was not supplied with any special figures or facts, and it was not opinions that were wanted, but he maintained with certainty, that during his experience there had been a great falling off in industrial efficiency through lost time, caused by drinking Prior to the change of hours by which the starting hour in shipbuilding is now 7.30 instead of 6 a m, the statistics that had been placed before him showed clearly that the number of men working on Mondays was much less than on any other day in the week, and the number working on Tuesdays had been less than on the four later days of the week; and, of course, the fact that these men were not present to do their work affected the employment in which they were engaged, and their efficiency. In regard to the accidents, where it had been stated that there were more accidents on Mondays than on other days of the week, it was important to remember that these accidents in his experience were not calculated in proportion to the number of men who were at work, and, as the number of men at work on Monday was decidedly less than on any other day in the week, and a larger number of accidents occurred on Monday than on other days, the fact was emphasised that accidents were more likely to take place on Monday than on other days With regard to the question as to whether abstainers or non-abstainers were more efficient, that might be considered from two points of view. He could say, with absolute certainty, that employers relied more on the abstainers, because they were the better men, taking everything into consideration. They were more reliable, more peaceable, and their example was a great benefit to other men and to the industry. It was often said that in many cases men who drank were better workmen than those who were abstainers, and there were, undoubtedly, many cases of very good workmen who were, at the same time, drinkers. One explanation of that, and he thought an important one, was given to him by a Newcastle physician, as the reason, and that applied in the case of some of the shipowners, who were of opinion that the drinkers were sometimes better than the abstainers. The fact was this, that the clever workman, who was not a drinker, rose to a higher position, and became a foreman, while the clever workman, who was a drinker, did not rise, and although he was still a clever workman, he remained a workman. He thought there was a great deal in that. In regard to the question of housing, they were often told, especially by those who spoke on behalf of the drink trade, that it was the wretched housing conditions that led to drinking, but was it not the fact that, as far as bad housing conditions were concerned, it was the drink that was the cause, because a man preferred to spend his money on drink, rather than on a good house? In his own experience, he had known men who were capable of earning more than a pound a day, who grudged spending more than three or four shillings a week on their houses, although they had large families.

Mr. Alfred Rorke said that Sir Thomas had referred several times during his lecture to the fact that alcohol was a stimulant, and asked the question why the workman took drink. It was obvious they took it for stimulation. The previous speaker had referred to America, but he did not say how the question of drink in connection with America was to be dealt with, because there was any amount of secret drinking in America, and as long as alcohol was a stimulant, some means must be sought of regulating and administering it. Last week there was a discovery of cocaine being smuggled into this country, and the authorities seized it and took it to the hospitals. Why did they take it to the hospitals? Because it was a stimulant. In regard to the general use of alcohol by the population, and the question of clever workmen and drink, they were up against rather a difficult question, because it was on record that there had been no first class poet, and no first class musician who had been a total abstainer. They were dealing with the question of drink amongst workmen. The drinking habits were not entirely restricted to the working classes, and he had known many managers and proprietors who were terrible drinkers. When it became a question of stimulation, let them take cocoa. Who on earth could drink cocoa for stimulation? A coroner's officer had told him, in numerous cases of sucide, on a *post mortem* examination, it was found that the people were full of cocoa, and when people threw themselves over Waterloo Bridge, they frequently had a drink of cocoa beforehand at the coffee stall at the end of Waterloo Bridge. It really amounted to this. That as long as there were human beings on this earth, they would seek stimulant, and it was the duty of scientists to tell people how they should take it, and how they should regulate it exactly, as in the case of the cocaine which had gone to the hospitals.

Miss Rose E. Squire (Home Office) said the paper had included many points of great interest, and one that she might mention particularly was in regard to the beneficial effects of factory legislation, and the establishment of welfare conditions on women em-

ployed in the laundry industry. She believed she was the first woman to inspect laundries, and when she looked back, and saw the difference between the conditions at the laundries, and of the women employed there then and now, she thought she could say that there was a very great difference between the improved conditions of employment and those that existed when the Act of 1895 became law. When she first inspected laundries, beer was brought into them twice a day by potmen, and that was a great temptation to women who were addicted to drink, and who worked excessively long hours in heat and steam. Women engaged in laundry work now-a-days, were a most self-respecting class, and had got a reputation for diligence and sobriety. In regard to men's employment, she was of opinion that conditions had not on the whole improved in the same degree that the conditions of woman's employment had improved. The Home Office Welfare Orders, however, applied equally to men and women, and one of the improvements that had resulted from one of the welfare orders, and one which contributed to the sobriety of the worker was the requirement that pure drinking water should be installed in every factory. Until that order was made, in 1917, even in works where heat was excessive, it was very exceptional to find means of obtaining drinking water.

MR. A. PATRICK said he did not think there had been any investigation made in regard to the recent boycott of beer by doctors, or as to what the result of that boycott was, as to the results of it in relation to efficiency of the work done by the dockers, but he believed that if statistics were obtainable, it would be found that there was increased efficiency during the time that the strike was in progress. In regard to the medical aspect of the question it was interesting to know that the London Temperance Hospital, during the time it had been in existence, had treated no fewer than 44,020 in-patients, and when certain prescriptions had to be given, they were entered into a book, and then the alcohol had to be administered as a drug, and in its pure form, not in the way of wines, beers or spirits. So far as the question of prohibition in America was concerned, he thought that what evidence was coming from across the water, was more in favour of total abstinence than against it, and he believed that if the evidence on both sides was thoroughly sifted, it would be found that prohibition was going to remain, in spite of what its opponents had to say against it.

SIR THOMAS OLIVER, in reply, expressed his gratification at the general tenor of the discussion. Although the question of alcohol had been thrashed out a great many times, no settlement had yet been arrived at. In regard to prohibition in America, and what the extent of improved efficiency would be, no one could tell at the present time. Professor Fisher was a very strong advocate of it; and if he thought that it would result in a ten per cent. efficiency, Great Britain, as a country, could not stand out and let America have that start in the race. In regard to what Sir George Hunter said respecting workmen and abstinence, he thought there was no doubt that all round, if one wanted reliability, an abstainer could be relied upon more than a non-abstainer, as he was at work all the time, and was generally a good worker. There was no doubt that in many cases, when men went to work on Monday morning, they had not got rid of the alcohol that they had been consuming on the Saturday and Sunday, and their brains not being perfectly clear, the men did not exercise caution, and the result was an increase in accidents. Sir Thomas gave an interesting statement of his experiences in regard to cocaine, when it first was discovered and used as a drug, and said that in treating a patient who occupied a very high public position in the North of England with cocaine, the patient told him that he was stimulated to such an extent that he felt he could fight the whole council. Sir Thomas said we now knew cocaine to be a deadly poison, and to be avoided at all costs. As Mr. Patrick had observed, there was a great change in the minds of medical men with regard to the application of alcohol, and the profession did not use it now in the way it was used some years ago. It was used occasionally, but the limit which could be consumed in the body in about 24 hours was about two ounces. He did not see the bottles of brandy now-a-days that used to be found in a sick bedroom years ago, and medical men rarely ordered more than from two to three ounces of alcohol during the 24 hours.

On the motion of the CHAIRMAN, a vote of thanks was accorded to the author for his lecture, and the proceedings then terminated.

THE JERKED BEEF INDUSTRY IN BRAZIL.

Xarque is dried and salted beef, known in English as jerked beef. At present the largest amount of xarque produced in Brazil, both for home consumption and for export, is made in the southern and south-central States, namely, Rio Grande do Sul, lower Matto Grosso, and Minas Geraes, where there are 74 xarqueadas. Thirty-five of these plants are in Rio Grande do Sul (although only 26 were operating last year), 27 in Minas Geraes, and 12 in Matto Grosso. Besides these there are others situated in Sao Paulo, Parana. Goyaz and Rio de Janeiro, but their exact number is not known. The 74 xarqueadas have an annual production of over 50,000 tons of xarque.

Although the majority of the xarqueadas are situated in the southern part of Brazil, the

northern sections of the country are great consumers of this product, the xarqueadas having been established in the south because they were pushed out of their original sites in Argentina, Uruguay, and Paraguay, by the packing houses, against which they could not compete, and because cattle can be raised more profitably in the milder climate of the south than in the hot northern States, where large numbers of cattle die each year from the drought. According to official figures, there were 8,918,270 head of cattle in the State of Rio Grande do Sul at the close of the year 1919. This shows a gradual increase since 1915, when there were 7,793,108 cattle in the State. From the year 1915 to 1918 the numbers of cattle killed for the manufacture of xarque were 483,514, 469,327, 667,932, and 535,998 respectively. In 1920, 644,543 head were killed to make xarque. By way of comparison it may be noted that the frigorificos used 352,180, 361,120, 265,000, and 380,000 head, respectively The exportation of cattle on the hoof in 1915 was 18,235 head; in 1916, 11,250; in 1917, 26,272; and in 1918, 41,454 head; 957,442 head of cattle were used for all of these purposes in 1919

According to a report by the United States Assistant Trade Commissioner, at Rio de Janeiro, that city is the central distributing point for xarque, and the markets of the north are supplied from there. In the year 1920 281,234 bales, weighing 24,021,690 kilos, were brought into Rio de Janeiro, 61,618 bales of which were re-exported to the north and 223,103 bales consumed locally.

The following figures show the amounts of xarque exported from Brazil during the years mentioned:—

Year	Quantity. *Kilos*	Value *Milreis*
1902	63,796	56,137
1909	645,000	314,521
1912	13,981	14,816
1913	20,554	22,182
1914	138,306	135,863
1915	2,265,080	2,164,692
1916	7,121,603	7,555,949
1917	8,728,015	9,830,254
1918	4,809,316	7,296,008
1919	5,556,389	7,699,782
1920	7,889,072	10,213,077

The nominal value of the Milreis is 1s. 4*d*

During and since the year 1915 the exports of xarque have greatly increased, but contrary to general opinion this was not directly due to the war, for over 95 per cent of all xarque exported went to Cuba, either directly or via Uruguay. Except in 1917, when France bought 394,887 kilos and the United Kingdom 65,440 kilos, shipments to these countries have been very small. In 1916 Spain imported 291,035 kilos of xarque from Brazil, and 100 kilos in 1917, but has taken none since.

GENERAL NOTE.

VICTORIA AND ALBERT MUSEUM: INTERNATIONAL THEATRE EXHIBITION.—The final arrangements for the International Theatre Exhibition, which is to be held at the Victoria and Albert Museum, with the co-operation of the British Drama League, the Actors' Association and other societies and individuals connected with the Stage, are now being completed. The whole of the exhibits from the recent Exhibition at Amsterdam have been received at the Museum, and considerable additions have been made to the British, American, French, Italian and other sections A dark-room is being fitted up, to contain about 100 lighted models of theatre scenes. The catalogue is now in course of preparation, and it is hoped that the Exhibition will be opened on June 1st or 2nd. Information with regard to the nature and scope of the Exhibition can be obtained from the following members of the Publicity Committee:—St John Ervine, 9, Arcade House, Temple Fortune, Hendon, N W; Ivor Fraser, Electric Railway House, Broadway, Westminster, S W 1; E O. Hoppé, Millais House, Cromwell Place, S.W. 7; Walter Payne, 25, Charing Cross Road, W.C. 2; Horace Shipp, "Theatre Craft," 4, Bloomsbury Place, W C 1; Geoffrey Whitworth, The British Drama League, 10, King Street, Covent Garden, W C. 2; Martin Hardie, Victoria and Albert Museum, South Kensington.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesdays:—

MAY 24 (at 8 p.m.)—GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland." SIR GEORGE T. BEILBY, D.Sc., LL.D., F.R.S., Director of Fuel Research, in the chair.

MAY 31 (at 3 p.m.)—LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

MAY 26.—SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture." The RIGHT HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, in the chair.

JUNE 23.—F. W. Woods, C.I.E., late Chief Engineer, Irrigation Department, Punjab, "Irrigation Enterprise in India."

Date to be hereafter announced:—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION

FRIDAY, JUNE 9, at 4.30 p.m.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, MAY 15.. British Architects, Royal Institute of 9, Conduit Street, W., 8 p.m. Mr. J. A. Gotch, "The First Half-Century of the R.I.B.A."

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev E L Langston, "The Times of the Gentiles in relation to the End of the Age."

Geographical Society, Kensington Gore, S.W, 5 p.m. Mr. E. A. Reeves, "The Evidence of a True North and South Directive Force in the Atmosphere."

University of London, King's College, Strand, W.C., 5 p.m. Prof G. B Gray, "The Place of Sacred Gifts in Hebrew Practice and Thought" (Lecture II)

5.30 p.m. Dr. Don Rafael Altemira, "The Contemporary History of Spain." (Lecture V).

TUESDAY, MAY 16 Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W C, 5 15 p m. Discussion on "The Scientific Value of Life Tables," to be opened by Dr. M. Greenwood.

Royal Institution, Albemarle Street, W., 3 p.m. Prof. W. Bulloch, "Tyndall's Biological Researches and the Foundations of Bacteriology." (Lecture I.).

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. J F Shepperd, "Natural Colour Photography."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. Mr. Maurice Thiéry, "Le Théâtre d'Edmond Rostand." (Part I.)

University of London, King's College, Strand, W.C., 5.30 p.m. Mr. C. A. Brayley-Hodgetts, "The Influence of English Literature on Russian Thought."

5.30 Dr. H. W. Carr, "The Principle and Method of Hegel." (Lecture III).

WEDNESDAY, MAY 17.. People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Thomas Oliver, "Physical Conditions in Relation to Health and Output."

Meteorological Society, 49, Cromwell Road S.W., 5 p.m.

Microscopical Society, 20, Hanover Square, W., 8 p.m. Annual Pond Life Exhibition.

University of London, King's College, Strand, W.C, 5 p.m. Dr. A. Harker, "Geology." (Lecture I.).

5.30 p.m. Prof. Van Bemmelen, "The Morphological Character of the Skin Pattern in Insects and Mammals."

Bankers, Institute of, River Plate House, Finsbury Circus, 5.30 p.m. Annual General Meeting.

Automobile Engineers, Institution of, Y.M.C.A. Hall, Albion Place, Leeds, 7.30 p.m. Prof. G. E. Scholes, "Experiments on Cams and Poppet Valves."

Constructive Birth Control Society, Essex Hall, Essex Street, Strand, W C., 8 p.m. Mr. Aylmer Maude, "The Proposal of the Doukhobors to Murder their own Children."

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W. Conference, 10 a.m. 1. Sir Cyril Kirkpatrick, "Recent Improvements in Transport Facilities in the Port of London." 2. Capt. M. H. P. Riall Sankey, "Wireless as an Aid to Transport." 3. Colonel C. H. Bressey, "The Design Construction and Maintenance of Highways in Relation to the Development of Mechanically Propelled Vehicular Traffic."

THURSDAY, MAY 18.. Chadwick Public Lecture, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Sir Lawrence Weaver, "Rural Re-Settlement and its Relation to Public Health." (Lecture II.).

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, 8 30 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Prof. F. Keeble, "Plant Sensitiveness." (Lecture II.).

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Chemical Society, Burlington House, Piccadilly, S.W, 8 p m. Informal Meeting.

University of London, King's College for Women, Campden Hill Road, W., 4.30 p.m. Prof. V H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture IV.).

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W C., 6 p.m. (Kelvin Lecture) Prof. Sir Ernest Rutherford, "Electricity and Matter"

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S W., 10 a.m. Conference continued. 1. Mr. N. Chamberlain, "Inland Water Transport a Practical Policy" 2. Sir J E Thornycroft, "The Future Development of Road Vehicles for Passenger and Goods Services."

FRIDAY, MAY 19. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m Mr F. V. Russell, "The Operation of Heavy Surburban Passenger Services on a Steam Railway, with particular reference to Density of Service, Terminal and other Facilities."

At the Institution of Civil Engineers, Great George Street, S.W., 10 a.m. Conference continued. 1. Mr. D. H. Davies, "The Finance of the Modern Highway: A Problem and a Solution." 2. Prof. J. Carlier, "Foreign Railway Practice" 3. Col J. W. Pringle, "Safety in Railway Operation"

Electrical Engineers, Institution of (London Students' Section), Savoy Place, Victoria Embankment, W.C., 7 p m Mr. A. H. Reeves, "The Elimination of Atmospherics in Radio-Telegraphy."

Philological Society, University College, Gower Street, W.C, 8 p.m. Anniversary Meeting.

Geologists' Association, University College, Gower Street, W.C., 7.30 p m. Mr H. Dewey, "The Sources and Transport of Non-Local Rocks in the London Area."

Royal Institution, Albemarle Street, W., 9 p.m. Prof. Sir William Bragg, "The Structure of Organic Crystals."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. A. Weill, "Economic Politique Internationale." (Part III.).

University of London, at the London School of Economics, Houghton Street, Aldwych, W.C., 5 p.m. Dr. P. Giles, "Modern Views of Indo-European Origins." (Lecture II.).

At the Birkbeck College, Bream's Buildings, Fetter Lane, E.C., 6 p.m. Dr. E. Russell, "Recent Work with regard to the Influence of Soil Conditions on Agriculture." (Lecture II.).

Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. F. W. G. Clark, "Engineering Business in China."

SATURDAY, MAY 20.. Royal Institution, Albemarle Street, W., 3 p.m. Prof. G. W. Richardson, "The Disappearing Gap between the X-Ray and Ultra Violet Spectra." (Lecture II.).

Municipal and County Engineers, Weymouth, South Western District Meeting.

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday morning of the week preceding the Meeting.

Journal of the Royal Society of Arts.

No. 3.626 VOL. LXX.

FRIDAY, MAY 19, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 24th, at 8 p.m. (Ordinary Meeting). GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland (Coal, Peat, Water Power.)" SIR GEORGE T. BEILBY, D.Sc., LL.D., F.R.S., Director of Fuel Research, in the Chair.

FRIDAY, MAY 26th, at 4.30 p.m. (Indian Section.) SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture." THE RIGHT HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, in the Chair.

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 10th, 1922; SIR MARTIN CONWAY, F.S.A., M.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society:–

Hansard, John Henry, Bookham, Surrey.
Munshi, Trambakrai M., London.
Ryland, John William, J.P., F.S.A., Rowington, Warwick.

The following candidates were balloted for and duly elected Fellows of the Society:

Ahuja, M. R., B.Sc., Amritsar, India.
Bhan, S. N., B.Sc., Madura District, India.
Curtis, S. Rumson, Newton Abbot.
Duxbury, George C., Margate.
Giffard, Edgar Osbert, Hove.
Gillespy, George Thomas, A.M.I.Mech.E., M.I.Mar.E., London.
Horne, Robert Alexander, M.I.N.A., Rangoon.
Lance, Ernest Solomon, A.M.I.E.E., Llandudno.
Maartens, William Jacobus, Bloemfontein, South Africa.
Mehta, Jehangir Merwanji, Bombay, India.
Mehta, Manubhai Nandshankar, C.S.I., M.A., LL.B., Baroda, India.
Moss, Charles Samuel, Moose Jaw, Sask, Canada.
Patel, Hormusji Dossabhoy, Bombay, India.
Rowlandson, Major Charles William St. John, London.
Saxona, M. Amba Prasad, Rajputana, India.
Shank, John Verrall, Coorg, S. India.
Sharman, Dr. B. D., B.A., M.B, M.R.A.S., Calcutta, India.
Shaw, Pran Krishna, B.A., Bengal, India.
Verheyden, Dr. Cornelius, London.
Veriee, N. M Suleman, Mombasa, Kenya Colony.
Woods, William, London

A paper on "The Design of Repeating Patterns for Decorative Work" was read by MAJOR PERCY A. MACMAHON, R.A., LL.D., D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, APRIL 4TH, 1922.

COLONEL THE HON. SIR JAMES ALLEN, K.C.B., High Commissioner for New Zealand, in the chair.

THE CHAIRMAN, in introducing the author, Sir Thomas Robinson, said that he was one of the old stock of Britishers who helped materially to make the Dominions what they were. He was a man of imagination, and after having served his country in Queensland for some years, came home and served his country as Agent-General of Queensland for the longest period that any one had occupied the office. He was in London when the war broke out, and immediately offered his services to the British Government, becoming the Director of the Imperial Meat Supply.

For his services he had been rewarded with the Grand Cross of the British Empire, and had also been honoured by France, Italy, Belgium and other countries.

The paper read was:—

NEW ZEALAND.

By Lieutenant-Colonel Sir Thomas Bilbe Robinson, G.B.E., K.C.M.G.

There are very few places in the world which can offer such attractions as does New Zealand, both to the man who is desirous of adventuring his fortune in the out-lying parts of the Empire, and to the traveller in search of places of interest and beauty, and it is regrettable that there are not a larger number of visitors and settlers in New Zealand, but this is doubtless due to want of knowledge of the Dominion.

The means of communication between Great Britain and New Zealand are good and there is a choice of several interesting routes.

As I was anxious to see the Panama Canal, I made the voyage on board one of the New Zealand Shipping Company's Regular Line of steamers from Southampton to Auckland, and as the vessel called at Newport News, passengers had the opportunity of visiting Washington (as we did) and also seeing something of the West Indies, as the steamer called at Kingston, Jamaica.

The journey through the canal was the more interesting as we were following the American Atlantic Fleet, which was passing through the canal to join the Pacific Fleet, and on our arival at the other end of the Canal (at Panama) we saw the whole of the American Combined Fleets, a sight never to be forgotten, but I was glad to see at least one man-of-war there flying the Union Jack in such good and genial company.

The voyage across the Pacific from Panama to New Zealand was safely accomplished in most agreeable weather, and any possible monotony was broken by a short stay at Pitcairn Island, where we had the opportunity of making the acquaintance of some of the descendants of the mutineers of the "Bounty," a very interesting experience which one is not likely to forget.

Auckland, our first port of call in New Zealand, is situated in the North Island. The entrance to the harbour is very fine, and its beauty greatly impressed those of us who had not visited New Zealand before.

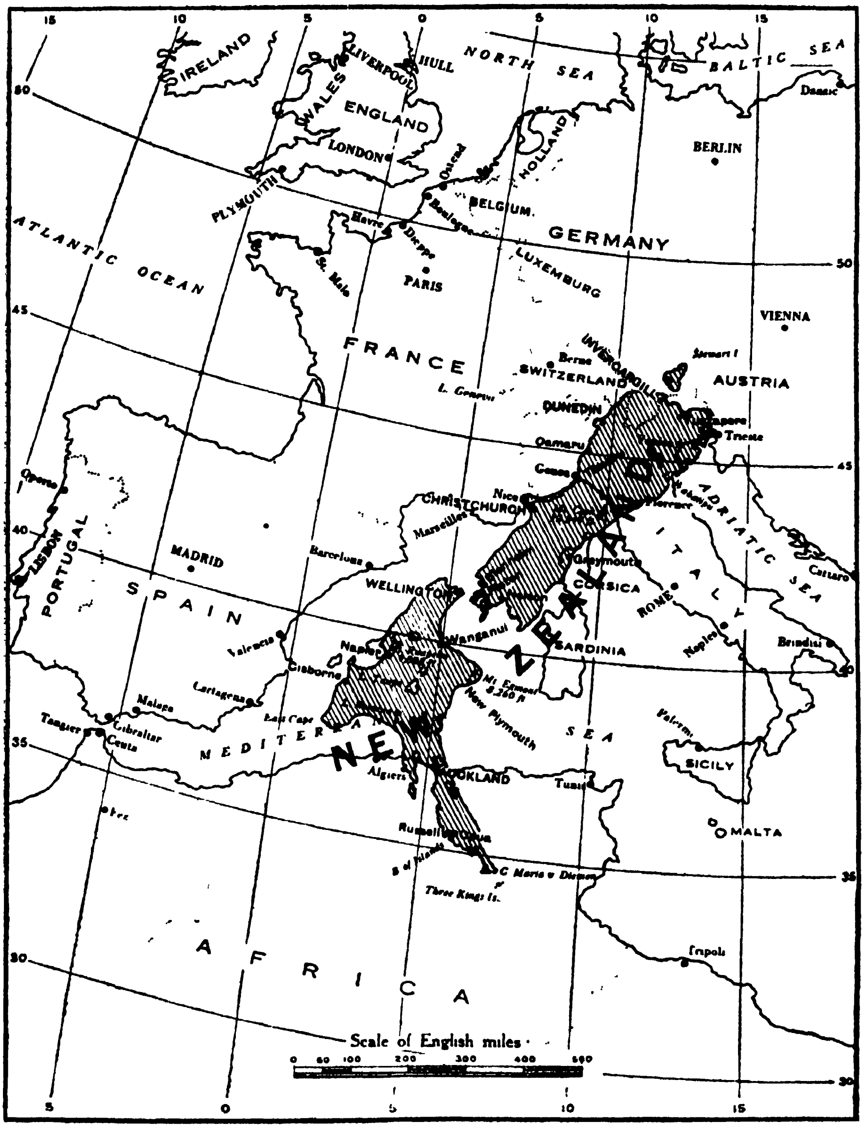
Auckland is a fine city, with excellent shipping accommodation, but it is somewhat hilly for the pedestrians, although the undulating ground upon which the city stands adds greatly to its beauty and attractions in other respects.

The country around Auckland is exceedingly beautiful and we were at once struck with the great variety of foliage and with the more green and homelike appearance of the country when compared with Australia.

Probably the most beautiful spot in the neighbourhood is on the summit of the hills which form the high land of the Isthmus upon which Auckland stands. From the residential portions of the suburbs situate on this delightful eminence it is quite possible to view the sea on both the east and west sides of the island, but this is of course only possible at that particular point where the island is most narrow and nowhere else do the east and west coasts so nearly approach each other. The view from this high land is exceedingly beautiful, but this is only one of the many beauty spots in New Zealand, of which there are so many.

Words fail one in the endeavour to describe the many beautiful places which we saw in both the North and South Islands, all of which are worthy of a more prolonged visit than we were able to pay, but with the help of the lantern slides which follow presently some idea may be gathered of the charming and delightful character of the country. Of course all these lantern slides lose greatly by the fact that they show only the form and not the colour of the objects photographed. Some day, perhaps, when colour-photography becomes more popular and more easily practicable, it may be possible to do something more like justice to New Zealand landscapes. Those of us, however, who have actually seen the places are able, although imperfectly, to imagine the colours with which the landscape was flooded and beautified by the gorgeous sunlight and the wonderful cloud effects which make New Zealand skies so glorious.

I am not bold enough to attempt to express any balanced comparison between the several parts of the North and South Islands, the attractions and the advantages are so various and the natural wealth of the several districts so abundant. The wonderful fertility of the



MAP SHOWING NEW ZEALAND,

as it would be situated if placed in corresponding latitude of Northern Hemisphere, but with east (instead of west) longitude, for comparison with countries on the Mediterranean Sea.

Owing to the position of New Zealand in the Pacific Ocean its climate is more equable and temperate than that of countries bordering on the Mediterranean Sea. The summer months coincide with the winter months in the United Kingdom.

MEAN TEMPERATURES.

AUCKLAND :—		WELLINGTON :—		ROME :—	
January ...	66.7	January ...	62.4	July ...	76.5
July ...	51.8	July ...	47.5	January ...	44.1
Annual ...	59.3	Annual ...	55.2	Annual ...	59.7

soil, and the bountiful pasture available for stock, are sufficiently evidenced by the exports from the Dominion, and the extent to which New Zealand's prosperity and commerce may develop in the near future seems to depend more upon the number of successful settlers who may be attracted to her shores than upon any other limitation.

Broadly speaking, it has been determined by Nature that the North Island should be the warmer of the two. The many warm springs, steam blow-holes and evidences of active volcanic forces—often at no great distance from the surface—give a special character, and perhaps even a greater interest to this part of the Dominion, and it is fortunate that successive Governments have realised how easy it is to increase the attractions with which Nature has endowed this highly favoured Dominion.

As an instance, one remembers how Rotorua has been made more beautiful and attractive to the tourist and holiday-maker, and how much natural beauty has now been disclosed and made accessible to those who are attracted by the natural wonders which exist in that most extraordinary district.

Visitors are made welcome on the tennis courts and bowling greens, and also find the hotel accommodation all that could be desired. The hot baths and the steam blow-holes are only some of the natural curiosities which have been appropriated and improved in the lay-out and the adornment of the Pleasure and Flower Gardens, which form a striking feature of this delightful holiday resort.

The Maori Settlement at Whakarewarewa is comparatively near, and is most interesting, not only because of the present Maori Settlement there, but because of the ancient Maori stronghold, or Pa, which has, happily, been maintained in an excellent state of preservation, and is situate in such a commanding position that it may be said to be one of Nature's fortresses. The obstacles and trench formations with which the early Maoris were shrewd enough to add to the strength of the position, suggest in a most remarkable manner the form of trench which was found to be suitable for the campaign in Flanders during the recent Great War.

Travelling in both islands by railway is quite comfortable, and on the railway line there, we travelled for the first time in the type of carriage which is popularly known in New Zealand as the "bird-cage." These carriages resemble our corridor coaches, except that the corridor is, as it were, out of doors, being only covered in by the roof, the side being composed of very open wire-work, which permits an almost unrestricted view of the country through which the train may be travelling, to those who are desirous of seeing it, and who sit outside the enclosed portion of the coach. The structure of the latter occupies about three-quarters of the width only, and thus leaves a kind of verandah upon which one may travel in comfort and enjoyment, especially during the hot weather.

The fact that the railways, both in the North and South Islands, run frequently within sight of the sea, adds greatly to the interest and enjoyment of travel, and the abundance of water, both in rivers and in lakes, throughout the Dominion, greatly increases the beauty and natural advantages of the country.

In the North Island, the large number of hot springs, and, in some cases, boiling pools, are a never-ending source of interest and attraction to travellers, and at Whakarewarewa we saw the Maori children sitting upon a piece of rock which separated a fast-running trout stream from a boiling geyser-like hole, so close to the running stream beside it, that the children were cooking in the boiling spring on one side of the rock a fish which they had only just caught with a hook from the trout stream on the other side, which seemed to be abundantly supplied with fish.

The Maoris' idea of a good site for a house and economical cooking, seemed to be over a moderately warm patch, so that in the winter time, the escaping steam would warm the interior of the house, and then to have a boiling pool as near as possible to the verandah steps, so that the wife might sit out on the verandah with her potatoes or pudding in a string bag immersed in the boiling water hole, and observe the passers-by, or chat with her neighbour while she watched the cooking of the family meal in progress by help of kindly Nature, being all the time at hand to take the string bag containing the food out of the boiling water when the cooking was completed, and the food fit for table.

We went from Rotorua to Wairaki, where the Rest-house accommodation was again most comfortable, and a morning walk up the adjacent valley, among the hot springs and geysers, was one of the

most interesting that we were able to make. The periodicity of these hot water geysers is so well known that it is possible to visit all by the help of a time-table, and be there at the moment when they are in the greatest activity. They vary even where two or more hot springs discharge into the same cavity of the rock, and the guides are able to tell you at what time each particular geyser will next display its greatest force and beauty.

It is impossible to conclude what one desires to say about this particular neighbourhood without reference to the wonderful steam blow-hole, which it is desirable to see at night, when the immense masses of vapour can be illuminated with coloured lights, and so rendered extremely beautiful by this and other means. In order to display the enormous force of this blast of steam, it is customary for visitors to throw in empty kerosene tins and watch them being projected into the air and falling again to the ground, the noise they make in falling mingling with the noise of the steam escaping through the rocks.

We were informed that the pressure of the steam at the point of its escape from the rock exceeds 350 lbs. to the square inch, and it is common knowledge that this escape has been in operation for the last fifty years without a moment's cessation. Up to the present, no attempt has apparently been made to harness this immense force, or turn it to some beneficial use, although it appeared to us from the conformation of the rocks through which it issues, that this might be accomplished with comparative ease, and at a very moderate cost. It is true that this escaping steam is at some distance from any present settlement, but it does seem a great pity that no steps have yet been taken to utilise such a bountiful and apparently inexhaustible source of power for commercial or beneficial purposes.

Fortunately, on the outward voyage, one of our fellow passengers, who had made the journey down the Wanganui River, had shown us some photographs which indicated, but all too inadequately, the natural beauties of that wonderful river and the country through which it passes. In order to see it for ourselves, we went up by rail to Taumarunaui, and there joined a small launch which was of sufficiently shallow draught to enable her, under ordinary circumstances, to get down through the shallows and over the rocks with which the upper portion of the river is beset. At the time we were there, the rainfall had been somewhat less than usual, and, in consequence, the water in the river was low. The launch which usually made the passage had evidently been stuck down the river on some of the crossings, and so we started from Taumarunaui in a smaller craft, but a few hours later came upon the larger vessel, which it had been found impossible to bring up any higher that day. We trans-shipped into the larger launch, and the change was very welcome, for we had been joined by a few other passengers, including a number of Maoris, and the more roomy accommodation of the larger launch was much appreciated. It also gave us opportunity to move about and make the acquaintance of some of our fellow passengers, who, knowing the district, were good enough to tell us something of the country through which the river flowed.

The boats were steered and poled by Maoris with great skill. In some places the water was so shallow that the boat could only be got over the rocks and rapids if the passengers disembarked and made the stage on foot, re-joining the launch again at some distance down the river where the deeper water permitted its navigation with passengers on board.

We stopped at a number of places on the way down, occasionally disembarking and picking up passengers and mails. At one point in particular, we were very much amused by the farewell which was being given to some of the Maori passengers by their friends and relatives, although the passengers who joined us were only expected to be away for a few days.

By sundown we had reached the house-boat moored about one third of the way down, where we spent the night most comfortably, and started again immediately after breakfast at 6 a.m. next morning.

We had intended to go right down to Wanganui, but a telegram intimating that Mr. Massey, the Prime Minister, was anxious to see me, reached us, and we, therefore, determined that, as the most interesting parts of the river had been passed, we would disembark at Pipiriki, where we arrived at noon on the second day.

We left Pipiriki by motor car and went over some very beautiful pasture land and wooded country to the railway, and so got into Wellington a few hours later.

Before leaving the North Island, we, of course, saw some of the other rivers, as well as some of the larger lakes, and we are never likely to forget the wonderful fishing which we enjoyed at Lake Taupo and on the Waikato River. The newly-caught fish cooked upon the beach on the fire and on the hot stones, made the water picnics most enjoyable, and the fishing far exceeded anything which we had thought possible. The sport was wonderfully fine, and the fish were game, of good size, and were most delicious eating. In fact, we came to the conclusion that for the trout fishing alone, it was well worth making the voyage to New Zealand.

In one of the rivers where we were fishing we were told the fish were so plentiful that at one season of the year it was no unusual thing to see the wild pigs catching them and eating them; they are so thick in places that the pigs, by wading into the pools where the fish are accustomed to congregate, manage to catch them in their mouths quite easily.

Speaking of fish reminds me that near an old Maori redoubt, which we visited in company with Judge Aitchison, with whom we happened to be fellow-travellers, we saw a lake into which an underground river discharges and from which, once a year, a very rare species of blind fish issues, but for a short time only, for after a few hours they return from the lake to the underground river from whence they came. During that short period, however, the Maoris, who know the day on which the fish invariably come out, catch them in great numbers and dry them for use as winter food.

It was in the North Island that we first saw the Maoris at home and among their natural surroundings. The difference between the Maori and the Australian Aboriginal is very striking. Physically the Maoris are greatly superior to most of the Australian Aboriginals and in their habits, their mechanical attainments, their intelligence and their nature they are very different from the natives of Australia. In nearly every instance we found them to be naturally intelligent, polite and friendly folk. They have great self-respect and in many ways they are accustomed to meet their fellow white Colonists on equal terms. They are a most interesting race and are of a most hospitable disposition. Their pride of descent is great and their knowledge of their ancestors is most accurate. The ownership of the land is easily ascertained and can be accurately settled because of the knowledge which the Maori possesses of his progenitors and their possessions, the land being held in common by the family or tribe settled in the respective districts. By a wise provision of the law the sale of Maori owned land must be made through Government channels and the Maoris greatly appreciate the fairness with which the sales of land have from time to time been negotiated by the Government on their behalf.

The traditions of the Maoris go back to very remote periods and in the distant past their settlement is said to have resulted from the arrival of large canoes laded with their ancestors, who came from other islands under the direction and guidance of bold leaders and great medicine men.

Maori folk-lore is extremely interesting. The mentality of the Maoris is distinctly poetical, and their knowledge of their past history is handed down from generation to generation with such care and faithfulness that in many cases it has been possible to obtain from the tribal traditions clear and fairly accurate history of their past.

The natural phenomena among which they live seems to have influenced the minds and impressed the imagination of the Maoris in the most wonderful manner. There are innumerable evidences of their poetical imagination and the following is a typical example: —

> "Mount Kakepuka is situated in the "Valley of Waipa It has fern covered "slopes and culminates in a crater-like "summit 1,400 feet high. Kakepuka is a "perfect type of an extinct volcano.
>
> "A few miles east of Kakepuka stands "Kawa, a rounded hill with a crater on "its southern side and its slopes cut into "the terraces of an ancient Pa. In the dim "long ago, says the Maori tradition, "these mountains were sentient beings "with human-like passions. Kawa was "a female mountain, Kakepuka was a "male and in those days there stood "near Kakepuka and Kawa another "hill called Karewa, who also was a male "mountain. Kakepuka came originally "from the south searching for his father "and was strolling about the Waipa "Valley in a mountainous sort of way "when he espied Kawa, the daughter "of Mount Pirongia and Taupiri and fell

"in love with her, so he remained there "by the side of Kawa Hill. Karewa "and Kakepuka both made fiery and "fierce love to Miss Kawa, quite after the "primitive fashion of volcanoes, and being "jealous of each other quarrelled. The "result was a titanic fight, a battle of "mountains. Karewa was badly beaten "by his big rival and had to trek. He "took up his rocky traps in the night and "marched westward by way of Kawhia, "striding into the deep ocean, and there "he let down his moorings and stayed "where the dawn found him, and so out "in the Tasman sea sits the lone Isle of "Karewa (which the Pakeha calls Gunnet "Island), while back in the valley of "the Waipa, Mount Kakepuka keeps a "majestic watch over Kawa, his gently "rounded, fern clad spouse. Kakepuka is "the weather glass of the countryside. "When he puts on his white cloud cap "and his old crater mouth is hidden in "fog and mist, it is better to strap your "rain-coat to your saddle bow. But "when on Kawa's ferny head the soft wet "mists come down, and when the long "wispy streamers of damp smoke-like "vapour cling round her terraced slopes "and are wafted over the plains on the "gentle seaward blowing breezes, 'that "is Kawa sending her tearful Miki of "love and sorrow to her far-off lost lover "Karewa."

That the Maori is fit to take his place beside the white man in the defence of his country, was surely demonstrated by the heroic manner in which he upheld the reputation of his race alongside the other New Zealand soldiers who fought in the Great War. There is no doubt that the race has, in the past as well as in the present, produced great warriors and sturdy men of war.

Even yet there are traces of the fortifications and defensive works upon the battlefields on which great Maori tribal wars were fought in by-gone days, and around these linger traditions which are happily being preserved, and which will for ever make the places with which they are associated of interest to students of New Zealand history. But I must not any longer linger over this and other subjects and places that make the North Island so attractive, nor is there time to do justice to the many interests, political and commercial, which are centred in and about Wellington and the other ports and places which we visited.

The crossing from the North to the South Island is by ferry steamer of magnificent size and equipment, and is comfortable, even in bad weather.

One of the two vessels engaged in this service leaves Wellington every night, and reaches Lyttelton in the South Island early the next morning. The railway journey from thence to Christchurch (through a somewhat remarkable tunnel) is accomplished in a very short time.

Christchurch is a very charming and well-planned city. In some respects it has advantages over Wellington, and has certainly a charm and beauty entirely its own. Through the centre of the town runs the river; lined with green, grassy banks, and flowering shrubs and trees, this is a never-failing source of interest, and adds greatly to the beauty of the city.

As in Wellington, there is a good tram service, and the surface of the surrounding country, as well as the site of the city, is, in contrast to Wellington and Auckland, wonderfully flat and even, thus favouring easy locomotion.

In one important respect, there is a striking difference between the Southern Australian States and New Zealand; for while in Victoria nearly the whole of the shipping and commerce is centred in Melbourne, and in New South Wales so much of the shipping and commercial life is centred in Sydney, no such concentration exists in New Zealand. Presumably this is because of the numerous ports along her coasts, at each of which the exports from the surrounding districts make it worth while for over seas vessels to call, with the result that there are a number of ports in both the North and South Islands regularly visited by overseas steamers, each port enjoying and developing its own overseas trade. In consequence, there are quite a number of large towns and cities already existing, and in course of development, and this so distributes the centres of commerce and population throughout New Zealand, that the congested and overgrown capitals of some of the Australian States have, happily, no parallel in New Zealand. This is, of course, greatly to the advantage of the latter Dominion, and results not only in a better distribution of the population, but also in a happier combination of town and country settlement than has yet been attained in

most of the Australian States. With the development of a number of important ports and cities such as exist in both Islands of New Zealand, closer settlement goes hand in hand. These several cities and ports give a near-at-hand market to producers, and foster a local patriotism and spirit of friendly emulation which must be of great advantage in the settlement of the Dominion.

The interest taken by Sir Joseph Kinsey in Antarctic discovery and the assistance which he rendered to those lion-hearted sons of the Empire is well known, and while at Christchurch we had more than one opportunity to hear from him details of the voyage of the S.Y. "Discovery" and the mishaps and adventures of Scott and his devoted fellow-voyagers. Sir J. Kinsey was good enough to show us his treasured relics of the expedition and we are indebted to him for some of the excellent lantern slides which we shall see presently. His collection of New Zealand native green stone ornaments and tools is of course very fine, but it was surprising to find in so unexpected a place such exquisite and interesting miniatures together with many other beautiful things including a varied and valuable collection of Japanese swords.

Our friends were so good to us there that I find it a pleasure to linger over a gossip about the pleasant recollection of our visits to Christchurch, as it was to postpone, as we did, more than once, our departure from that city because we liked the place and the people so much.

From Christchurch we travelled south by railway through some very beautiful scenery (especially in the neighbourhood of Port Chalmers) to the southern point of the South Island, and in Invercargill we were taken to see a well-known landmark, which was none other than an ordinary cast iron lamp post, such as one sees in many suburban streets in England. The interest attaching to this particular light-bearing standard arises from the fact that it is the nearest lamp-post to the south pole.

From Invercargill we went by rail to Kingstown and from thence by lake steamer to Queenstown. The latter half of the journey was particularly interesting, because of the majestic scenery by which the lake waters are surrounded, and to our great delight we were able, while upon this passage, to see the mountains known as the Remarkables covered with snow. The snow was an unexpected addition to the beauty of the landscape and had, as a matter of fact, fallen only the day before.

Queenstown is a comparatively small township, and although we were told it has less than a thousand inhabitants, it already possesses some very beautiful recreation gardens and terraced walks laid out upon a promontory jutting into the lake, just opposite to the landing stage. Our stay there was all too short, for there was some very interesting mountain climbing possible, which began almost at the hotel door.

Visitors to Queenstown should certainly take a drive to Skippers. The journey up the Range and through the Gorge to the site of the sluicing operations is exceedingly interesting and beautiful. On the one hand the road winds along the face of precipitous cliffs which rise abruptly to great heights from the narrow shelf along which traffic is possible, while on the other hand there is a sheer fall of, in some cases, hundreds of feet into the ravine below through which a raging torrent can be both seen and heard finding its way to the lower country.

The contour of the rocky formations assumes forms which are both majestic and grotesque. At one place we were shown an immense out-crop of rock on the mountain side which was called "Edinburgh Castle." At another place the outline of a far-off hill resembled the profile of Queen Victoria. There were other places and perilous passes whose weird names I shall avoid repeating for fear they should discourage travellers from making a most interesting journey which they might ever afterwards regret they had missed.

I do not mind confessing that, when the journey was over and we were safely back again, we felt that a watchful Providence had been good to us that day, for the very small margin of safety between the outer wheel track and the edge of the rock was surprisingly small at places, and I wonder to this day what happens when two vehicles meet on that long and narrow shelf, where there seems, except at one place (a little settlement) no room whatever for one vehicle to pass another. As there is no provision for enabling one vehicle to pass another on the track I am still wondering whether it is worked on the lines of a single track railway by a system of driver's staff, or some wonderful method of signalling which so operates as to

prevent more than one vehicle travelling on the road at any one time.

Of course the track is impossible for motor cars and only pedestrians and horse vehicles are allowed to use it.

At the time we were there, no gold to speak of was being recovered, but we were fortunate enough to secure a specimen of the alluvial gold which is sometimes found in this locality and which we have brought home with us as a treasured souvenir of a most adventurous and delightful day, but only one of the many which we spent in New Zealand.

We climbed one of the big hills there, called "Ben Lomond," until we got well into the snow line, and then, as the snow began to fall again, we thought it prudent to abandon our intention of climbing to the summit, but we did so with great reluctance, for the view from the hill across the lake, both in the direction of Paradise (which is situate at the head of the lake) and toward the Remarkables on the other hand, was worth climbing a long distance to see.

From Queenstown we went by motor car across country to Mount Cook. Our adventurous journeys across the Crown Range and through Lindis Pass, were full of interest and delightful, as well as, sometimes, somewhat disconcerting experiences. A broken down motor car on a mountain range, calls for mechanical skill which is not always available, and when our difficulties which arose from that cause were (after some hours' delay) happily overcome, we were exceedingly glad to partake of the kindly hospitality of a road mending party, the members of which turned out of their bunks long after dark to boil water and make us tea, while they regaled us with welcome chunks of bread and jam. It gives me great pleasure to express, on this side of the globe, our appreciation of the great kindness which we experienced at the hands of this road party, and the gratitude which we felt for their kindly hospitality after a long mountainous journey, upon which we had had plenty of hard work, a long trip in the dark without lights, and with nothing to eat for many hours.

We waited at Lindis Pass until another motor car came to our rescue. Here we were in the deer country and it surprised me to find that in some cases settlers found it necessary to erect fences eight to ten feet high to prevent the deer, of which there were a large number in that locality, from jumping over into the cultivated areas and eating up or destroying the crops. We had venison and rabbit for every meal, and fared sumptuously there, as we did also everywhere else in New Zealand. There had been no need for rationing there, for they have had fruit and food in abundance always.

From Lindis Pass we continued our journey across country, but, happily, upon this occasion in a motor car not quite so liable to break down as the one in which we had made the first part of the journey. We travelled over excellent country and good pasture land (as yet very sparsely settled) for the greater part of the way. The roads were exceedingly good and we made excellent running until we arrived at the Resthouse at Pukaki, the last stage before reaching Mount Cook. Our progress at this point was arrested by a telephone message which had come through from Mount Cook, stating that there had been heavy rain along the road, and that Wood Creek was running in flood in consequence; that a motor car, which had attempted to get through that morning had got into deep water, and had, in consequence, been abandoned in the Creek, which, for the time being, was impassable. We waited for a few hours, and then, having word that the Creek was reported to be falling, we made up our minds to attempt the journey, although it was now so late in the afternoon that no inconsiderable portion of the journey would have to be made in the dark. We reached Wood Creek without mishap, and ultimately managed to get across, although we had a bad five minutes when our motor stopped in the Creek only about forty or fifty yards away from the abandoned car, which was almost submerged. Our driver promptly jumped out into the water and managed to start the engine again, and with the help of the Road Superintendent, who was good enough to accompany us, we managed to zig-zag across on to higher ground; the water was never much above the floor of the car, and we ultimately got safely across. Being the first passengers to make the crossing subsequent to the rising of the Creek, our arrival was anxiously looked for at Mount Cook by the people who were waiting for the Creek waters to subside, and when our head-lights were sighted, they waved us a lantern welcome, and by the time we reached the Hermitage

they had made a most abundant dinner ready for us, much to our satisfaction and enjoyment.

The Hermitage Resthouse, maintained by the Government, is at the foot of the Mount Cook Gorge. It is exceedingly comfortable and well appointed. Visitors are not, as yet, so numerous as one would expect them to be, but the organisation and arrangements generally for accommodation, climbing and guidance of visitors, are all that could be wished. The kindly interest and the courtesy shown to us and other visitors by Mr. Peter Graham, the chief guide, added much to the pleasure of the visit to Mount Cook.

The view from the Hermitage of the surrounding mountains is indeed very beautiful and at sunset the gorgeous colouring of the snow-capped peak of Mount Cook is most brilliant and beautiful beyond description.

We were fortunate while in New Zealand to make the acquaintance of two gentlemen who had climbed to the summit of Mount Cook, and as both have published a full and interesting account of their experiences we were fairly conversant with the details of their climb and journey to the top, but our interest was greatly increased by the further details which were elicited in conversation with the climbers, and in particular with Mr. Turner, the only man who has made the ascent alone and reached the summit without guide or assistance. We are inclined to think that the eventful journey which he made alone after several years of preparation and waiting for a favourable opportunity, had been prompted by some question which arose as to which member of the party who made the ascent previously should be conceded the greatest credit for the mountaineering skill exhibited on that occasion; but after the solitary climb of the gentleman named there could, of course, be no question as to his mountaineering skill and indomitable courage, no matter to what extent the same could be claimed for the others in whose company he had made the earlier climb.

Although none of our party attempted such an adventurous trip as the ascent of Mount Cook, we were all keen to climb some portion of the mountains by which we were surrounded, and as we were favoured with exceptionally fine weather we were able to make several ascents, but of course of only minor importance.

The Stocking Glacier being within comparatively easy distance of Hermitage Resthouse, we began there, and although the climb was exceedingly difficult and tiring in places we ultimately reached the glacier, where we saw the most wonderful colours in the snow cavities and caves. The extraordinary effect of the passage of the ice through and over the rocks gave one a very vivid idea of the extent to which the movement of a glacier over the surface of the country may alter the features and contour of the valleys through which it passes on its way to the sea.

In years to come the Alpine fastnesses of New Zealand will surely attract many climbers, and I venture to suggest to the Alpine Club that if the mountains in New Zealand were better known they would attract climbers from England in spite of their distance from this country.

From Mount Cook we travelled eastward towards the coast, spending a few delightful days with some friends upon both sheep and cattle stations. We should have liked to prolong our stay so that we might have seen more of the Dominion, but we could not spare any more time, as it was necessary for us to go on to Australia without further delay.

Although I have mentioned some of the fish which may be found in abundance in the lakes and rivers, I have said nothing about the sea-fish, which abound on the coast. Among the lantern slides we shall find a picture of "Pelorus Jack," the extraordinary fish which used to pilot every ship which passed through Cook Strait from Wellington to Christchurch for years, but is now apparently dead, as he has not been seen for some considerable time.

Then there is the extraordinary Frost Fish, no specimen of which has ever yet been caught either by line or net, and which can only be found if sought for on the beach after a frosty night. It is an excellent table fish and is regarded as a great delicacy.

New Zealand birds deserve a lecture all to themselves. There are some very interesting and very beautiful specimens, but I will only mention two. First the delightful little fantail, which flits about one's head and accompanies wanderers in the bush and in the gardens in the most extraordinarily friendly and confiding manner. I have never succeeded in getting one to perch upon my finger, but have frequently

induced them to perch on a short stick held in my hand for that purpose. The birds are of course wild and are very graceful and beautiful in appearance.

The other bird to which I refer is the kea and is of quite a different character. He has in some way discovered that the kidney of a sheep is agreeable to his palate and in his vicious attempts to secure the desired delicacy he kills the unfortunate sheep by tearing open its back, and curiously enough just at the identical spot at which the kidney can be most easily abstracted from its ill-fated owner.

There is so much that might be said about the wonderful strides which have been made in the dairying industry and the success with which butter and cheese are produced and graded, exported and marketed. In this respect New Zealand is said to be still in advance of Australia.

That New Zealand contributes an important proportion of the mutton and lamb upon which British consumers depend for their food is, of course, well known, but time forbids my dealing with this subject upon the present occasion.

There is an abundance of fruit in New Zealand. In some of the gardens at Christchurch we saw as much fruit which had fallen off the trees and was lying on the ground as would have stocked Covent Garden Market, and there is no doubt that in the near future New Zealand will successfully compete with Australia for a share of the British markets, so far as apples and pears are concerned.

If time had permitted, I should like to have said something about the gum industry, the growth and cultivation of flax, and the steps which have been taken to maintain and increase the growth of timber, and in this connection I would like to mention that on one of our journeys we passed through Crown Lands, of which 25,000 acres had been closely planted with young pine trees. This had all been done by prisoners' labour, a very excellent way of employing prisoners and one which is said to have a beneficial effect upon their subsequent conduct. It is impossible however to do justice to any of these subjects in the time at my disposal.

In conclusion let me say that to those who have leisure to visit the more distant and beautiful parts of the Empire, New Zealand offers many attractions and a hearty welcome, while to those in search of greater opportunities and brighter surroundings than the Old Country now affords to some of her people, New Zealand offers the promise of success and prosperity which seems to follow so certainly upon the industry and effort of those who are privileged to live within her borders. We Australians may perhaps be insufficiently informed as to the attractions from which we are separated by a short sea voyage and are consequently missing opportunities of a delightful change in neglecting to visit New Zealand more frequently than we do, but the safety, progress, and prosperity of the Dominion and the Commonwealth are so inseparably connected that as time passes the bonds and associations by which we are united must inevitably be increased and strengthened to our mutual advantage and the good of the Empire.

DISCUSSION.

The Chairman (Colonel the Hon. Sir James Allen), observed that New Zealand was a country of great production and he should like to have descanted upon it at some length if time had permitted. He would have to content himself by saying that it was a land of beauty and imagination, a place for tourists, a place for those who were seeking their health, not only on account of the climate but because of the natural hot waters and springs, and a place of sport. These aspects in New Zealand were not sufficiently known to the people of Great Britain. There was, he believed, no more beautiful country in the world, and no country that boasted such a variety of scenery of all kinds in so small a place as New Zealand. He thought they could get the best trout fishing in the world there; trout up to 37 lbs. could be caught with rod and line. Salmon were now running in most of the rivers, while in the seas around the country a different type of sport could be got in catching kingfish, which ran up to 80 lbs., and were also caught with rod and line. They could imagine what sort of sport an 80 lb. fish would give an angler on the rod and line. As to the health resorts, if they wanted to go to a place where they were almost certain to recover from diverse complaints —he would not say all complaints—they should go to New Zealand and sample the hot springs and the hot baths and the climate and the sun and the atmosphere. Then, if they wanted to give full play to their imagination, they could enjoy the mysteries of the stories of the Maoris and of ancient times, and though New Zealand was prosaic in regard to its products of mutton and beef and lamb and butter and cheese and wool there was another side to the lives of its population, and that was one it was as well to cultivate. The native of New Zealand had been referred to by Sir Thomas Robinson,

and all he said on the subject was true. There were no finer natives in the world than the Maoris and the Polynesians. When the war broke out the Maoris were the first to come forward. Out of a comparatively small population, 3,227 joined the fighting forces, and those who came in contact with them during the war agreed that they were as good soldiers as could be found anywhere. They volunteered in the early stages, and their volunteering was always free and full. When the Military Service Act was introduced he had a special clause inserted to authorise him as Minister of Defence not to apply the Military Service to the Maoris unless he deemed it necessary. The Compulsory Act was not applied to the Maoris until towards the end. There was one tribe who thought they had a grievance against the whites, a very old one. He was obliged to apply the Act to that tribe, and one of the men who came to camp went back to the rest and said "I have my experience of camp and think you should all come in." The whites lived happily with the natives, who were given equal opportunities.

THE HON. A. M. MYERS, Member of the New Zealand National Ministry, 1915-1919, remarked that no one who had visited New Zealand as a tourist had ever been disappointed. He was asked to say a few words from the probable settler's point of view. When representatives of all the Overseas Dominions were urging that their own particular state was the most suitable for emigrants, no greater testimonial could have been given to New Zealand than the fact that they had from Sir Thomas, a former representative of one of the sister states, Tasmania, such a splendid eulogy of New Zealand. In New Zealand they had practically no unemployment. Financially, like other countries, they had been passing through difficult times, but they had a population which was most virile, very industrious, and living in surroundings in every way conducive to turning out millions' worth of products attractive to customers on this side of the world. He did not for a moment hesitate to suggest to anyone who was desirous of leaving the Mother Country that he should direct his steps to New Zealand. Her trade, principally with the Mother Country, per head of population was larger than that of any other country in the world. The laws were very liberal; they had enjoyed the full franchise for over a quarter of a century; free access to the land was given to people of comparatively small means; and although they had had a land boom, owing to the high price products realised during recent years, now there was no doubt that land would be obtainable at a reasonable price in the future. The price of their staple products was improving. There had been a set back, but there was no doubt they had turned the corner, and the future of New Zealand was as bright as it could possibly be. Any emigrant, if prepared to be industrious and frugal, was assured of success.

SIR JAMES MILLS, K.C.M.G., Chairman of the Union Steamship Company of New Zealand, in proposing a vote of thanks to the author said he hoped that Sir Thomas Robinson's excellent address would find its way to many thousands of readers, and so stimulate their interest in the dominion to which many of those present belonged and were proud to belong.

MR. BYRON BRENAN, C.M.G., in seconding the motion said they had been reading lately about the question what they should do with their sons, and the answer to that question had been given that evening.

The motion was carried unanimously and acknowledged by Sir Thomas Robinson.

NOTES ON BOOKS.

THE PETROLEUM INDUSTRY: A BRIEF SURVEY OF THE TECHNOLOGY, BASED UPON A COURSE OF LECTURES GIVEN BY MEMBERS OF THE INSTITUTION OF PETROLEUM TECHNOLOGISTS. Editor, A. E. Dunstan. London: The Institution of Petroleum Technologists, 5, John Street, Adelphi. 1922. 14*s*. 6*d*. net.

Here we have an unusually satisfactory example of that difficult literary operation of so ordering a large number of contributions as to produce a well fitted and sequent whole. Thus the reader of this book has before him a clear, readable, exact and well illustrated story of petroleum, from the earliest mentions to that climax in use, the modern Diesel engine for marine purposes.

The numerous illustrations of this volume of 346 large octavo pages, and the notable thoroughness with which the main-line aspect is considered, are the chief factors which give it the exceptional quality of being equally useful to the general reader and to the expert technologist.

The constructive materials of the book are Sir Frederick Black's introductory lecture; Sir Boverton Redwood's Royal Institution lecture on the Romance of Petroleum; Mr. Cunningham-Craig on Wild-Catting; Mr. George Howell on Prospecting; Mr. H. May on Oil-field Practice; Mr. H. Barringer on Transport, Storage and Distribution; Mr. A. E. Dunstan (Editor) on Refining; Mr. F. B. Thole on The Chemical Nature of Petroleum; Mr. W. R. Ormandy and Mr. J. S. S. Brame on The Uses of Petroleum; Mr. J. Kewley on Nomenclature; Mr. A. W. Eartlake on Statistics, and Mr. W. H. Dalton on Text Books.

On p. 9, the reader may see a photographic illustration of a pitch spring at Zante, as

mentioned by Herodotus, who wrote about 2,400 years ago, and the picture shows the lifting of the viscous pitch from beneath the water by a tree branch, just as the Father of History describes the operation. It is, however, worthy of passing note that Herodotus refers to the matter as bearing on a Phœnician story he had heard, about a method of gold-getting by a surface smeared with viscous petroleum, a story so remarkable that Herodotus could not at first credit it: but a study of the mode of dipping out pitch at Zante led him to regard the story as probably correct. (Herodotus, cap. IV., sect. 195, p. 338 of George Long's text, London, 1851.) Herodotus incidentally touches on the tanking, and the storage in iars of the pitch at Zante. His Phœnician story as to gold getting may not seem altogether incredible to a modern laboratory worker who has studied certain aspects of surface tension and adhesion as affected by water, and an application of the notion to the separation of minute grains of heavy metals, which, like platinum, resist amalgamation, may be worth attention.

The old Burma oil well (Fig 2, p 23), the Assam oil field (Fig. 4), and the remarkable picture of a Mesopotamian refinery on p. 32, which latter suggests a desert studded with a few gipsy tents from which smoke issues, all savour of the slow-changing East, but when we read of Wild-Catting in the West (p. 36), the note changes The wild-cat is the first well of a new oil field, and if the field is good, the first spit of the wild cat is a torrential push, such as is vividly described on p. 37.

To minimise failure in wild-catting, there should be a wide combination of qualities in the prospector, who should be able to trace the various porous strata whether loose or compact; also, he must be able to judge as to the outlines and formation of the anticlines or subterranean dome-like receptacles in the impervious strata. In these anticlines which are often extremely irregular in formation, the natural gas collects at the higher levels, the oil in the medial levels and water below. As the pressure of the gas may be many hundred pounds to the square inch (p. 56), one can easily realise the active burst-forth on release.

Owing, however, to the highly complex conditions which are incidental to the subterranean domes—if indeed the term dome can be applied to such irregular inverted cisterns as are figured on pages 64 and 65—the surprisingly large areas which may be linked together by porous strata acting more or less as natural pipe lines, and also the many other matters set forth in Mr. Howell's section of the work, anything like uniform success in prospecting must appear almost impossible; yet it appears that in prospecting with ripe knowledge and careful study as an equipment, instead of mere or bare hope, as too often in former times, there may be, if not certainty, yet a very firm belief that the first or experimental well will yield oil.

So remarkable and interesting are the conditions affecting prospecting that the section on this subject may be studied as casting a side light on the problems of life, as in the case of a good novel or the study of chess.

"The Winning of Oil" is the title of the section which treats of engineering and other details of the operations from the driving of the well to the securing or first tanking of the crude product, and as this work is often carried out in districts void of fuel and water, an element of provision comparable to modern army commissariat steps in, even to the arrangement of games for the workers. The technical details of driving, jointing, percussion, drilling and "fishing" will open out many lines of thought to one with mechanical instincts. Under "Transport, Storage and Distribution," we read of tank ships and the organisation which brings "kerosine" to our doors, although at no stage has it been packed for transit.

The chapter on nomenclature, with glossary of business and colloquial terms as they have settled down by usage and tacit consent, is admirable because real *Gas*, for example, is not defined by reference to any law of thermodynamics, but we are curtly told that in the United States it is a short form for gasoline. It was, we think, Mr. Robert Barr who laid it down that a Briton finds American to be the easiest of all foreign languages as far as a superficial knowledge is concerned, but the most difficult of all in relation to a thorough scholarship.

The uses of petroleum are so diverse that the well illustrated sections on this subject offer the difficulty of choosing something for mention, but if the reader opens the book at pages 262 and 263, he will see how cows are milked by petrol drive and electric intermediary, and also two other illustrations of farm operations, but the consummation of the work centres on the Diesel marine engine, as figured on p. 309, and the illustrations of semi-Diesel principle shown on p. 304. Apart from the question of using the so-called "colloidal fuel" (a *quasi*-emulsion of petroleum and coal) in such engines, we are reminded on p. 69 that Canada alone gives reserves in coals suitable for distillation into liquid fuels of over 1,190,000,000,000 tons; while on pp. 5 and 6 the problem of growing liquid fuel in the form of alcohol is briefly considered.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesdays:—

MAY 24 (at 8 p.m.)—GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland." SIR GEORGE T.

BEILBY, D.Sc., LL.D., F.R.S., Director of Fuel Research, in the chair.

MAY 31 (at 3 p.m.)—LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections." SIR CHARLES J. HOLMES, D.Litt., F.S.A., Director of the National Gallery, in the chair.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

MAY 26.—SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Studies. (Sir George Birdwood Memorial Lecture.) "Indian Painting and Muhammadan Culture." The RIGHT HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, in the chair.

JUNE 23.—F. W. WOODS, C.I.E., late Chief Engineer, Irrigation Department, Punjab, "Irrigation Enterprise in India." LORD LAMINGTON, G.C.M.G., G.C.I.E., Governor of Bombay, 1903-7, in the chair.

Date to be hereafter announced:—

J. T. MARTEN, I.C.S., M.A., "The Indian Census."

DOMINIONS AND COLONIES SECTION.

FRIDAY, JUNE 9, at 4.30 p.m.—MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, MAY 22 .. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. H. Lee Shuttleworth, "The Border Countries of the Punjab Himalaya."

University of London, King's College, Strand, W.C., 5 p.m. Prof. G. B. Bray, "The Place of Sacred Gifts in Hebrew Practice and Thought." (Lecture III.), 5.30 p.m. Prof. F. H. Edgeworth, "The Development of the Head Muscles of Vertebrates." (Lecture I.)

TUESDAY, MAY 23 .. University of London, King's College, Strand, W.C., 5.30 p.m. Rev. R. G. Laffan, "The Serbo-Croat-Slovene Kingdom after the War." 5.30 p.m., Dr. H. W. Carr, "The Principle and Method of Hegel." (Lecture IV.). 5.30 p.m. Prof. F. H. Edgeworth, "The Development of the Head Muscles of Vertebrates." (Lecture II.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Technical Meeting.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Dr. B. Malenowski, "Theory and Practice of Witchcraft in Eastern New Guinea."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Mr. Cecil Clementi, "Colonisation in British Guiana."

Zoological Society, Regent's Park, N.W., 5.30 p.m.

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. Maurice Thiéry "Le Théatre d'Edmond Rostand." (Part II.)

Royal Institution, Albemarle Street, W., 3 p.m. Prof. W. Bulloch, "Tyndall's Biological Researches and the Foundations of Bacteriology." (Lecture II.)

WEDNESDAY, MAY 24 .. People's League of Health, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Dr. Leonard Hill, "Personal Hygiene and the Importance of Food and Sufficient Sleep; Standards of Living and Family Welfare."

University of London, King's College, Strand, W.C., 4 p.m. Dr. A. Harker, "Geology." (Lecture II.) 5.30 p.m. Prof. F. H. Edgeworth, "The Development of the Head Muscles of Vertebrates." (Lecture III.)

British Academy, at the Royal Society, Burlington House, Piccadilly, W., 5 p.m. Mr. E. Hutton, "Some Aspects of the Genius of Boccaccio."

Linnean Society, Burlington House, Piccadilly, W., 3 p.m. Anniversary Meeting.

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Very Rev. Dean Inge, "Theocracy." (Lecture I.)

THURSDAY, MAY 25 .. Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Piccadilly, W., 8 p.m. Annual Meeting.

University of London, King's College, Strand, W.C., 5.30 p.m. Rev. Percy Dearmer, "Central and North Italian Painters of the Fifteenth Century." (Lecture IV.) 5.30 p.m. Prof. F. H. Edgeworth, "The Development of the Head Muscles of Vertebrates." (Lecture IV.)

At King's College for Women, Campden Hill Road, W., 4.30 p.m. Prof. V. H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture V.)

British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Prof. E. A. Gardner, "Greek Public Buildings."

Royal Botanic Society, Inner Circle, Regent's Park, N.W., 6 p.m.

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W., 6 p.m. Major Hume, "The Seaplane's Place in Aviation."

Chadwick Public Lecture, Chelsea Physic Garden, Chelsea Embankment, S.W., 5 p.m. Mr. E. A. Bowles, "Superstitions of Early Herbalists."

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Anglo-French Society, Scala House, Tottenham Street, W., 8.30 p.m. Mr. R. J. O'Connor, "L'Ile Maurice, Etoile de la Mer des Indes."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. H. R. Sleeman, "The Re-establishment of the Gold-Basis of Currency."

FRIDAY, MAY 26 .. University of London, King's College, Strand, W.C., 5.30 p.m. Mr. Frantisek Chudoba, "Modern Czech Painting: Mikulăs Aleš (1852-1913)." At Birkbeck College, Bream's Buildings, Fetter Lane, E.C., 6 p.m. Dr. E. J. Russell, "Recent Work with regard to the Influence of Soil Conditions on Agriculture." (Lecture III.)

Royal Institution, Albemarle Street, W., 9 p.m. Prof. W. E. Dalby, "The Internal Combustion Engine."

Physical Society, Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.

Public Health, Royal Institute of, 37, Russell Square, W.C., 4.0 p.m. Dr. W. M. Willoughby "Port Sanitation." (Lecture III.)

Municipal and County Engineers, Institute of, Town Hall, Kilburn, N.W., 10.30 a.m. Discussion on Mr. Wilkinson's paper, and visits to local works.

Engineers, Junior Institution of, Caxton Hall, Westminster, S.W., 8 p.m. Mr. J. C. Rennie, "Engineering Appointments and How to Get Them."

SATURDAY, MAY 27 .. Royal Institution, Albemarle Street, W., 3 p.m. Sir Hugh Allen, "Early Keyboard Music." (Lecture I.)

Journal of the Royal Society of Arts.

No. 3,627 VOL. LXX.

FRIDAY, MAY 26, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK.

WEDNESDAY, MAY 31st, at 3 p.m. (Ordinary Meeting). LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Problem of Provincial Galleries and Art Museums, with special reference to Manchester." SIR CHARLES J. HOLMES, D.Litt., F.S.A., in the Chair.

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING

WEDNESDAY, APRIL 5TH, 1922.

LORD HEADLEY, M.INST.C.E.I., in the chair.

The paper read was:—

COAST EROSION AND ITS PREVENTION.

BY PROFESSOR E. R. MATTHEWS, Assoc.M.Int.C.E., F.R.S. (Ed.), F.G.S.

INTRODUCTION.

The author in this paper discusses various matters relating to the encroachment of the sea., He describes certain natural formations which on some parts of our coast protect it from serious erosion, including Sea Beaches and Sand Dunes. He sets out the principal causes of erosion, briefly describing various types of artificial protection works. Reference is made by him to Deep-sea Erosion, the formation of Salt Marshes, Subsidence, and the findings of the Royal Commission on Coast Erosion.

THE COMPOSITION OF THE FORESHORE.

The foreshore and sea bed is usually composed of :—

(1) Rock (as at Troon, Ayrshire) or

(2) Boulders, large and small, eithe accumulations or isolated boulders or

(3) Shingle, or

(4) Sand, or

(5) Alluvium, or

(6) A mixture of some of the above.

Most of these materials have been derived from denuded cliffs, or, in the case of alluvium, have been brought down by rivers as mud, and accumulated usually in or near an estuary.

NATURAL PROTECTION OF CLIFFS AND LOW-LYING COAST LINES.

The pummelling action of the sea at the toe of a cliff formed of easily-eroded material, say, of clay overlaid with gravel and sand, results in time in the breaking up of the base of the cliff, and the removal by landslip of the gravel forming the top layer of the cliff. This mass of material, clay, gravel, sand and soil (which has fallen on to the foreshore) is immediately attacked by the sea at the next tide, and a sorting out process is carried on ; sand and other fine materials are carried off in suspension and deposited some distance away, or rolled along the foreshore by the action of the waves. The larger materials — pieces of clay, boulders and gravel, are forced by the waves up against the base of the cliff, and so form a very small and temporary protection to the toe of the cliff.

FORMATION OF SHINGLE BANKS.

(1) *The Chesil Bank** (Fig. 1).—This world - renowned shingle bank runs parallel to the Dorsetshire Coast, and is the most remarkable bank of shingle around

* "The Grading of the Chesil Beach Shingle," by Dr. Vaughan Cornish, Proc. Dorset Natural History Field Club, 1898.

"On the origin of the Chesil Bank," Joseph Prestwich, Proc. Inst.C.E., Vol. XL.

"Description of the Chesil Bank," by John (afterwards Sir John) Coode, Min. Proc. Inst.C.E., Vol. XII., 1853.

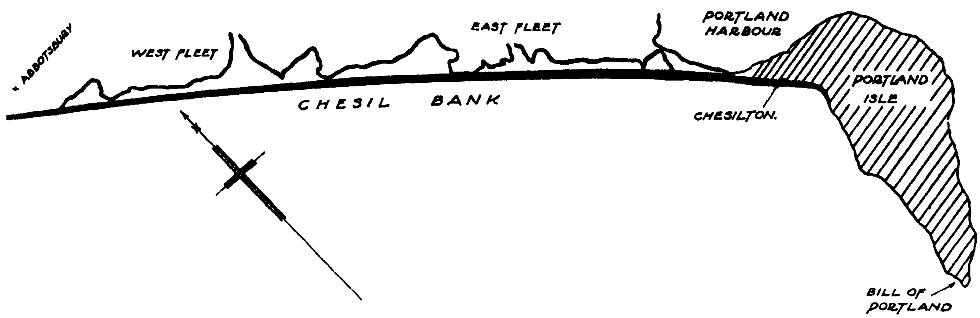


FIG 1.—The Chesil Bank.

our coasts. The bank commences near Abbotsbury, and extends 10¾ miles to the Island of Portland, which it joins at Chesilton. At the Portland end, the shingle bank sweeps round in a southerly direction nearly to Blackmore Point. Between the shore and this shingle bank is a sheet of tidal water known as the "Fleet"; this varies in width from a quarter to half a mile. The east end of the bank acts as a natural breakwater to Portland Roads in the east bay.

The average width of the base of this vast shingle mound varies from 600 feet at the east end to 500 feet at the west end. The height of the Portland end above L.W.S.T. is 53 feet, and at Abbotsbury 32 feet. The top is 43 feet and 23 feet respectively above H.W.O.S.T.

In the Dorchester Museum there is a collection of stones taken from this huge breakwater, and they are in the following order of abundance :—

(*a*) Chalk flints.
(*b*) Greensand chert.
(*c*) Portland limestone and chert.
(*d*) Quartzites.

The foundation of the bank is Kimmeridge clay at a depth of 8 fathoms of water.

The width of the channel between Plymouth and the coast of Brittany is about 112 miles. This narrows down to 60 miles between Portland Bill and Cap de la Hague, widening to the eastward again to over 100 miles.

This sudden contraction is responsible for the race of Portland on the north side, and the race of Alderney on the south side of the Channel. The velocity of the race off Portland Bill is 5 or 6 knots, and under certain conditions, 7 knots.

"Under the stress of its currents, combined with the blow of heavy gales, the old shingle beach has been steadily pushed back, and the present contours of the coast line created."*

In 1852 there was a terrific storm, and after this Sir John Coode took numerous sections to see to what extent the face of the bank had moved ; these showed that nearly 4 million tons of shingle had been swept down into deep water during this gale.

The bank in normal weather presents a slope of about 1 in 2½, but in severe on-shore gales, the crest assumes a slope of 1 in 9.

The rise of the water at Spring tides is 10 feet.

During heavy gales the waves breaking on the bank, throw the water and spray to a height of 60 to 70 feet, or 20 to 30 feet higher than the top of the bank.

On November 23rd, 1824, a ship was washed completely over the beach on to the Mere side. On September 9th, 1883, the sea broke over the beach, flooding the railway. In more recent years Chesil Street and Victoria Square have been flooded.

The origin of this ancient beach has been the subject of much discussion, and differences of opinion, but it is practically agreed that it could not have been derived either from the few flints produced by the waste of the cliffs near, or from the remains of the older beach which once existed further seaward. *"The flints of which the bank is mostly formed denote an inland rather than a sea cliff origin, and point to the time of the breaking up of the last great Ice Age, when the valleys and rivers were scooped out by the ice, and the floods due to its melting, and when vast quantities of rock debris and gravel were carried to the coast."

It is interesting to note that at one time the coast line was 10 miles at least further seaward than at present ; this is indicated

* "Tidal Lands," by A. E. Carey, M.Inst.C.E., and Prof. F. W. Oliver, D.Sc., F.R.S.

* "The Sea Coast," by W. H. Wheeler, M.Inst.C.E. (Longmans).

by the line of the old raised beach referred to which stretches across Lyme Bay.

The eroded cliffs contained a large amount of gravel and flints, which, falling on the beach, drifted landwards, forming a bank of increasing magnitude as the cliffs receded. Much of the material was doubtless derived from this source. The bank has, no doubt, reached its maximum size.

At the Abbotsbury end the mean slope is :—

1 in 7 to 3½ fathoms.

1 in 11 to 5½ fathoms.

1 in 30 to 6 fathoms where the shingle terminates.

The bank extends out into the bay at the Chesilton end 200 yards, where the water is 7 fathoms deep.

There are two ledges of rock running nearly parallel with the bank, one at about 5 miles from the shore in 10 fathoms ; the other about 10 miles in 15 fathoms.

Sir John Coode tells us that "the stones of which the bank is formed vary very much in size, the largest being at the Portland end. The graduation in size from the east to the west end of the bank is so regular that a Portland fisherman if landed on the bank in the dark would be able to tell his position from the size of the pebbles."

According to Coode large pebbles travel farthest because they move more readily than small ones ; Redman agrees to the greater travelling power of the large material as also does Reade. On the other hand, Prestwich, Palmer, Airy, Spratt and Geikie hold that the smaller pebbles travel farthest. The author agrees with this latter contention. The question as to whether the shingle travels east or west on the great Chesil Bank has long been disputed. (Fig. 2.)

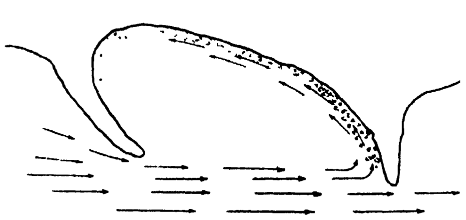


FIG. 2.—Movement of Shingle in an Embayment.

The theory accounting for the growth and development of the bank is that the prevailing south-westerly gales and currents bring the largest pebbles eastward, the pebbles dropping in the order of their size, the largest being carried farthest.

The author does not agree with this theory ; he suggests that while the travel of material along a coast is almost always in the direction of the flood tide, and the flood tide on this coast is from west to east ; yet on a coast indented by numerous bays as is the Dorsetshire coast, the drift in most of these bays is in the opposite direction to the flood tide ; the diagram illustrates this.

A glance at the map (Fig. 1) will show the projection southwards of the Bill of Portland and St. Albans Head. These promontories project into the famous Portland Race, which at certain seasons of the year has a travel of seven knots.

The Chesil Bank, where it joins the mainland by West Bay, Dorset, is composed of sand and very small shingle, which gradually increases in size to the westward. If the drift had been east as claimed, the natural result would be the deposit of the larger and heavier stones at West Bay and the lighter ones graduating in size would be carried along until the current was again deflected by the West Cliffs of Portland, and the finer material deposited at Portland end. This, of course, is contrary to the present state. Furthermore, the north end of Portland is clay, and the Chesil Bank is composed of blue clay overlaid with shingle ; this being so, is it not to be presumed that before the shingle covering overlaid the clay the heavy sea rollers from the Atlantic would have eroded the clay bank, making a breach and thus making Portland truly an island ? On the other hand, if we consider the Race, into which Portland Bill impinges, is it not reasonable to assume that the Cornwall and Devon deposits travelling along with this very strong current, will be deflected by this point of rock and carried into this sheltering bay, first northward and then westward along the West Bay ? This procedure would account for the larger material on the beach being at the Portland end.

It has been stated that marked bricks have been put into the sea on the Dorset coast west of West Bay and they have been found again at the Portland end of the beach. The author cannot vouch for this, but, even if it is correct, is it not possible that the bricks may have travelled first westward until drawn into the Race and then carried east until, striking Portland Bill they would be thrown clear of the main current and carried along the cliffs until

they came to rest at the first place suitable?

It is interesting to note that rudderless ships and sailing vessels in distress generally drift from south of the Bill northwards and travel almost parallel with the Bank, gradually drifting shorewards.

The author agrees with Coode, Matthews and Shield that with off-shore winds, the waves build up shingle beaches, while with on-shore winds beaches are denuded.

"When a small vessel is taken through the Race on Portland Ledge during somewhat rough weather, the decks are covered with sand deposited from the water which splashes over her. The Shambles shoal is undoubtedly maintained by this and other detritus settling from suspension in the repeated horizontal circulation of water eddying round a vertical axis on the east side of Portland."*

ISLAND OF PORTLAND (Fig. 1).

The eastern side is being wasted by the encroachment of the sea, and large portions of the cliff have fallen. About the middle of last century a serious landslip occurred and the cliff for 150 yards in depth fell into the sea.

This Island is composed of oolite limestone containing nodules and bands of chert resting on a bed of grey and yellow sand and Kimmeridge clay.

The highest point (which is some distance back from the Bill) is 488 feet above sea level.

Portland stone is quarried on this Island, and exported to all parts of the country, being used chiefly for building purposes.

The Island is connected with the mainland by a narrow isthmus along which runs the Chesil Bank.

(2) *Dungeness.* This is one of the most wonderful promontories formed of shingle to be seen around our coasts, and its origin may doubtless be attributed largely to the fact that the cliffs at Hastings at one time extended much further seaward than they do at the present time; and the shingle due to wasting back of those cliffs travelled east-the ward. Mr. Wheeler tells us that "this shingle gradually extended across the mouth of the estuary of the Rother and choked the outlet of the river which finally became diverted from its original course to Rye. The shingle bank thus formed led to the silting up of the estuary of the river, and the formation of marshes from which the tide was excluded, and the land reclaimed, by the existing artificial banks. The flood tide entering the new outfall eddied round and gradually drifted the shingle in a south easterly direction, and so formed the nucleus of the salient angle which now exists."*

The steady growth of the present shingle bank is due mainly to the shingle travelling on the South Coast in an easterly direction meeting the littoral drift moving along the east and south-east coasts in a westerly direction; these two opposing forces are causing largely the banking up of this shingle promontory as we see it to-day, it is gradually extending further and further seawards, and its face is so steep (2 to 1) that it is said that a large vessel could come near enough to the shore to enable a stone to be thrown on to its deck from the shingle bank.

The base of the triangle forming the headland is approximately 6 miles, and the distance from the base to the apex 3 miles. Since the time of Elizabeth, this promontory has been pushing forward at an average rate of 6 yards a year; the growth in recent years being at the rate of 2.61 yards per year.

The growth of this bank has pushed the harbour of Rye a quarter of a mile further out from the land. On several occasions the lighthouse has had to be moved further seawards. During the past 35 years the shingle has covered 430 acres to a depth of 7½ feet, representing 7,000,000 tons of shingle or 200,000 tons a year. The total shingle deposit covers an area of 6,000 acres.

(3). VARIOUS OTHER EXAMPLES.

(a) At Lancing on the Sussex Coast, there is a shingle bank about a mile long and 150 yards wide.

(b) On the East Coast the Aldeburgh bank extends southwards from Orford Ness for 9 miles, with a width of about 80 yards.
The river Alde once had its outlet to the sea across the marshes to the south of the town. This river (together with the rivers Ore and Butley) has been diverted from its course by the travelling shingle, and its point of discharge is now 9 miles further south than it was originally. At Aldeburgh the river

* "Waves of the Sea," by Dr. Vaughan Cornish (Unwin).

* "The Sea Coast," by W. H. Wheeler, M.Inst.C.E.

is only separated from the sea by a shingle bank 80 yards wide. It is stated that this bank has extended southward more than half-a-mile during the present generation.

The bank suffers most from north-east gales. Probably the only source from which this shingle has been derived is the pebbly gravel contained in the low cliffs 2 miles to the north, and those at Dunwich, 8 miles distant. There is a continuous beach all along this reach of coast, and the direction of the drift is from north to south.

(c) On the Norfolk coast a shingle bank extends from Weybourne in a westerly direction for 7 miles, terminating at Blakeney harbour. At Weybourne, the bank is about 100 yards wide at the base.

(d) On the Yorkshire coast a sand and shingle spit projects out into the mouth of the Humber for 3 miles, having a width of from 150 to 200 yards.

(e) Near Harwich harbour there is a similar spit.

These shingle banks stand out quite separate from the coast line, and have a marked effect upon the configuration of the coast.

(f) *French example.* Shingle banks may also be seen on the shores of the West of France: in the Bay of Audierna, Finisterre, there is a shingle bank 8 miles in length which extends in a southerly direction from the rocks in the middle of the bay at Penhors to Penmarck. The top of this bank is 16 feet above the beach, and behind it is a salt-water lake and salt marshes. The sea has occasionally broken through, but the gap has been at once restored by the drift of the shingle. The shingle is composed of pebbles of granite, gneiss, mica schist, and quartz derived from the erosion of the adjacent cliffs. The drift and flood tide are from north to south, the prevailing winds being south-westerly.

(g) *Filey Brig.*—This rocky promontory acts as a natural breakwater, and protects the town of Filey from heavy seas occurring in a northerly gale.

NORFOLK COAST.

(h) *The Wash.*—Into this estuary the Ouse, Nene, Witham and Welland discharge. These rivers drain 5,820 square miles. This estuary is 12 miles wide at the mouth and formerly extended 50 miles inland; it had a width of about 30 miles. The Romans, by the construction of over 50 miles of sea banks enclosed the greater part of this area, leaving only the Wash open to the tides.

The area covered by the tides is about 157,000 acres, of which 84,000 acres consist of sand beds dry at low water. These sands, according to old charts prepared in the early part of the last century, have practically retained their shape. Accretion is taking place along the shores of the Wash, especially on the west and south sides.

SAND DUNES.

On many parts of our coasts these may be found, and they form a natural protection. Nine-tenths of the coast line of the world is said to be fringed with sand. In Great Britain there are many square miles of *waste* dunes; these are mostly stationary, but in some places, as on the French coast, and the coast of Holland, there are large areas of shifting dunes which are a menace to the surrounding country, as they destroy in their inland march much fertile land. There is no reason why many of these should not be reclaimed, and in time be made productive. Mr. Gerald O. Case in his "Coast Sand Dunes" gives three ways in which human industry can be applied to coast sand dunes, and the author agrees with his suggestions. They are:—

(1) By forming on a sandy shore where there is now erosion, a protection dune; or one might be formed (on a sandy shore) in front of low lying land for reclamation purposes.

(2) By maintaining a coast protection dune (or dunes) either naturally or artificially.

(3) By reclamation of the landward dune area (which is usually a sandy waste) when the protection dune has been made secure.

There are many examples of reclamation work in sand dune areas at home and abroad. The French particularly have done useful work in this direction. On the Gascony coast of France sand dunes were driven inland by wind action, causing erosion of the coast and ruination to the land. All this has been changed by the work undertaken by the French Government. The success of this work was largely due

to the French engineer, M. Brômontier, who, over a hundred years ago devised a scheme for fixing the Gascony dunes. His scheme consisted :—

(a) In the formation of a coast protection dune on the shore line.

(b) In the reclamation of the dunes and sandy wastes on the land-side of this protection sand dune.

(c) In the cultivation on these dunes of various plants, and later of fir trees.

This work was found in time to be very productive.

On the coast of Lancashire the unblown sand has to a large extent been fixed by vegetation, and erosion prevented, especially in the neighbourhood of Southport ; but during the past 300 years the wind has formed a belt of sand from one to four miles wide between Formby and the Ribble estuary. Mr. Case says there is "insufficient vegetation to fix the sand dunes, and they are rapidly moving inland causing large areas of fertile land, and even villages, to be overwhelmed by the advancing sand and sand deserts are formed." *

There are many parts of our coast where reclamation as at Southport might similarly be carried out, and large sand areas which are now only partially protected by vegetation turned into valuable grazing lands.

The Dutch for centuries have realised the value of sand dunes in preventing the inroads of the sea.

It must not be supposed that sand dune embankments raised to their proper height, and fixed by vegetation, are always a cheap and reliable form of coast protection ; they will not be at all suitable on some coasts where there is a heavy wave action, and much erosion, but they will undoubtedly stand moderate storms if they are constantly kept in repair. Renewal of the vegetation will occasionally be found necessary, and in many cases it will be found advisable to protect the face of the embankment and occasionally the foundations. This may be done in many ways, reinforced-concrete being found to be a useful material for this purpose.

CAUSES OF COAST EROSION.

Coast erosion is not due to any one particular cause, but to many, some of which may be set out as follows :—

(*a*) By the pummelling action of the sea against the base of low-cliffs, and on low coast lines.

(*b*) Erosion caused by wind-formed currents acting below L.W.O.S.T.

(*c*) By the checking of the alongshore drift, as most harbour projections are doing, including Madras, Lowestoft, Yarmouth, Shoreham, Whitby and others.

(*d*) By springs and land drainage discharging down the face of the cliffs, assisted by wave action at base of cliff.

(*e*) By landslides, with battering action of sea.

(*f*) Rain and frost combined with wave action at base.

(*g*) By subsidence of the sea bed.

(*h*) Erosion of the bed of the sea due to wave action and currents.

(*i*) Removal by builders and others (often including Local Authorities) of shingle and sand from the foreshore.

(*j*) Obstructions left on the foreshore.

(*k*) Badly designed sea defence works ; especially faulty foundations.

(*l*) By the owners of adjoining lands doing nothing to stop the erosion in front of their own lands.

(*m*) By cutting marram and other grasses from the sand hills, and so removing the protection of the dunes from wind storms.

(*n*) By no attempts being made to construct protective works.

(*a*) WAVE ACTION.

When a wave breaks upon a shore its action is divided into three parts :—

The "plunge ;

the "shoreward" rush.

the "backwash" towards the sea.

It is the first of these, the "plunge," that does most damage, the ill effects of the "backwash" being next in severity. The plunge stirs up the sand and shingle, and some of this is rolled along the beach seaward, or, if sand, is carried seaward in suspension ; some of the material thus disturbed is rolled forward again by the next breaking wave, and it may be thrown up eventually by the sea or drawn seaward, much of it remaining just beyond L.W.M., and when the next storm occurs it may be lodged permanently at H.W.M.S.T.

It is not the intention of the Author to discuss in detail Wave Action in this paper, but only to refer to it briefly in passing.

Waves occurring in the open sea (as for example in the Atlantic), due probably to a hurricane blowing for several days on

* "Coast Sand Dunes," by Gerald O. Case.

the surface, do no harm to the bed of the ocean, which is miles below its surface, but immediately those waves reach shallow water, say, 150 feet in depth, they meet a shoal. It may now be observed that the water becomes agitated, due to wave action reaching to the bed of the ocean. As it rolls on into still less shallow and lesser shallow water, its action is felt more and more, and it is here that erosion and accretion begin to take place.

Some authorities have suggested that storm waves cannot have any effect on the bed of the ocean even in shallow water, but the author totally disagrees with this view.

(*b*) EROSION CAUSED BY WIND-FORMED CURRENTS ACTING BEYOND L.W.O.S.T.

While wave action is the principal cause of erosion, the material lying on the bed of the ocean, if the water is not deep, is affected by severe currents. In "Coast Erosion and Foreshore Protection," by Dr. J. S. Owens and G. O. Case, this is explained as follows :—

"The velocity of this translatory movement of water decreases from the surface downwards. When the wind commences to blow, the upper layers of water are drifted with the wind. This forward movement is gradually propagated to the lower "layers," and, if the wind continues, eventually produces a movement of the whole body of water, if not too deep. Vice-Admiral Makaroff, of the Imperial Russian Navy, made observations with a current meter on the velocity of the undercurrents in the Bosphorus, in depth up to 22 fathoms, and it appeared that the velocity, and, consequently, the eroding power, decreased progressively as the depth of water increased."*

OBLIQUE WAVES.

Waves striking the shore obliquely, do more damage usually, and remove more shingle, than those produced by a direct on-shore gale. For example, a severe south-westerly gale (continuing for some days) on the South Coast will cause the waves to strike the shore obliquely, and the greatest damage done is always during a gale from this direction. A direct off-shore gale (continuing for several days) often causes a heavy and destructive ground swell in which the waves break with considerable force. On the North East Coast much damage is sometimes done by such a ground swell.

* "Proc. of the Royal Society of Edinburgh," Vol. XXII.

(*c*) HARBOUR AND HEADLAND PROJECTIONS.

All seaward projections on a coast, whether they be in the nature of a groyne extending only to L.W.O.S.T., a breakwater, a harbour arm, or a promontory such as Flamborough Head or Spurn, extending seawards some miles, have the effect of checking the along-shore drift, and starving the coast on the leeward side of the projection.

Numerous examples of this might be given, including the cases of Yarmouth, Lowestoft, Whitby, Shoreham, Newhaven, and the glaring example of Madras. Space in this paper will not permit of a description of more than, say, three of these :—

Yarmouth.
Lowestoft.
Shoreham.

YARMOUTH.

This is one of the best examples of a harbour projection extending out into deep water successfully trapping and impounding the travelling sand, while for miles on the leeward side (the travel of material on the east coast is from north to south) the coast has been deprived of its natural protection and become denuded.

This harbour was laid out in its present form between 1660 and 1700.

"Millions of tons of sand have been impounded by the harbour projection, and acres of public gardens laid out on what was formerly a part of the foreshore, and there are many acres of sand which the tide never covers. About 1870 the harbour pier was extended some three hundred feet, and millions of tons of sand have become impounded since then. The trapping of the sand at Yarmouth has meant that for several miles to the south of the town the erosion has been alarming." *

LOWESTOFT.

This harbour was constructed in 1844 and has had a similar effect upon the coast north and south of it. A vast accumulation of sand has occurred immediately north of the harbour, covering an area of about 60 acres, and representing some millions of tons of sand. Large quantities of this are sold annually as ballast, and removed in barges. To the south of Lowestoft at

* "Coast Erosion and Protection," by E. R. Matthews (Griffin).

Pakefield the erosion is most serious, houses having been swept away by the sea.

SHOREHAM HARBOUR.

There is a natural indent in the coast at Shoreham, and a large accumulation of shingle had taken place between the foreshore and the river Adur, before the west pier of the harbour was built in 1874.

Since the pier was extended it has been impossible for any of the material to travel eastwards, and so the already vast shingle bank has grown, and it is now over a mile in length, a quarter of a mile in width, with an average thickness of 30 ft., or, no less than 9 million tons of shingle have accumulated.

The travel along this coast is from west to east, and the heaviest seas occur during south-westerly gales. A good portion of the impounded shingle, were it not for the projecting pier, would travel in an easterly direction affording a natural protection to Brighton and Hove.

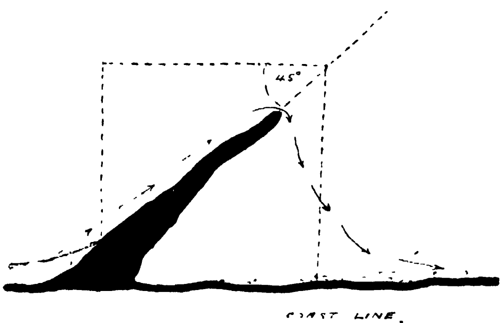


FIG. 3.—Headland Projection at 45° with Coast.

HEADLANDS. (See Fig. 3)

This same principle also prevails in regard to headlands; those promontories which project at right angles to the coast more perfectly trap the travel of material along the coast than those running out at an angle in the direction of the littoral drift. Flamborough Head and Spurn are good examples of this. In the case of the former the angle with the coast is 60°, and in the latter it is 25°.

GENERALLY.

The checking of the travel of material on a coast is a most important matter, for not only is material held up by the projection of say a harbour, but the harbour engineer is troubled by the fact that his harbour entrance is frequently blocked by sea-borne sand and shingle, and works constructed at great cost on sandy coasts have been fearfully expensive in maintaining; as examples we would say that the harbour of St. Catherine in Jersey which was begun in 1848 was subsequently sanded up, and was in consequence abandoned.

A second entrance to Rye harbour constructed by Smeaton, was, in a few years filled by the movement of shingle from the west. The most glaring example is the case of Madras, where the advance of the shore line out-ran the building of the breakwaters. Since this harbour was constructed the accretion of sand on the south side of the harbour has been enormous, and covers an area of 260 acres, while alarming erosion has been and is, taking place on the north "leeward" side of the harbour, and villages have been swept away by the encroaching sea.

During a storm at Port Said which continued for one or two days, about two million cubic yards of sand was deposited in the mouth of the channel; the available depth being reduced by 8 feet.

(*d*) SPRINGS AND LAND DRAINAGE.

Good illustrations of this are seen on many parts of the Holderness Coast of Yorkshire, and in the Cliffs between Walton-on-the-Naze and Frinton. The coast line just to the north of Bridlington also affords an excellent example of this.

(*e*) LANDSLIDES.

On many parts of our coast *landslips* are of frequent occurrence. One of the best examples the author has seen is in the Crag Cliffs near Walton-on-the-Naze. The Crag rests on a flat bed of London clay the level of which is about shore level, and the subsoil water in the Crag percolating down to the clay bed assists in this sliding action. Rain and frost, combined with wave action at the base of the cliff, assist considerably in this destruction.

(*g*) SUBSIDENCE.

The author has for some years been of the opinion that the sea bed, and most of our river valleys, are gradually subsiding. The land about the Mersey estuary has sunk during historic times; evidence of this is shown in the gradual rise of mean tide level at Liverpool.

Many evidences of subsidence might be given, but only two will be named.

(1) The remains of ancient docks 27 feet above the seal level may be seen in Crete.

(2) In some districts coal is being mined at depths of 3,000 feet below the level at which plants must have grown.

In spite of these and many other suggested proofs we find eminent geologists, such as Mr. Clement Reid, F.R.S., saying in his evidence before the Royal Commission on Coast Erosion that in his opinion:—"The rise of the sea level (*i.e.*, the subsidence of the land) may have been completed about 3,500 years ago, and only then commenced the coast erosion which we now see."

He also said that:—"About 3,500 years ago we get back to the beginning of the period of unchanging sea level in which we are still living."*

Other well-known geologists seem to support Mr. Reid's contention. Professor W. Boyd Dawkins, for example, in 1903, said he did not know of any depression of the coast line or changes of level in any part of the country that had not taken place before Roman times, and Mr. W. Whitaker, F.R.S., F.G.S., told the Royal Commission that he had no good evidence of movements now going on.

So there are conflicting views on this important subject.

Huge upheavals and depressions, of course, have occurred as a result of severe earthquake shocks; take the well-known Lisbon earthquake of 1755, when the site of the harbour sank 600 feet. The most striking example in recent times of upheaval was the raising of the beach at Yakutat Bay, Alaska, from 7 feet to 45 feet, in 1899.

In 1845 a wooden bridge was discovered near Birkenhead (presumably Roman), spanning a tributary of Wallasey Pool; the roadway of this bridge was 14 feet below the level of high tides.

"The existence of old roads running down to the sea at Seaforth, Crosby, and on the New Brighton Coast were apparently objectless, unless they at one time crossed the bed of the estuary."†

Evidences of depression are also to be found in submerged forests at various parts of the coasts of England; the author has seen a number of these. In the Alexandra Park at Hastings, for example, there is a tree trunk which came from a submerged forest some distance seaward of the outer end of the Hastings Pier. In their "Coast Erosion and Foreshore Protection," Dr. J. S. Owens and Mr. Gerald O. Case say they came across beds of peat six feet thick on the foreshore at Youghal, Ireland, with branches and trunks of trees embedded. At Deal, also, and on some parts of the Norfolk coast peat is to be found under the foreshore.

"During the excavations for the docks at Hull a forest was found at a depth of about 40 feet below high water, and in the Finlands some five buried forests have been discovered."*

(*h*) Deep-Sea Erosion.

Evidence of deep-sea erosion may be seen on almost any shore after a storm in the form of large stones with lengthy seaweed attachments. Such stones have been wrenched by storm waves from the rocky bed of the ocean and flung up on the shore; especially does this occur during on-shore gales. Coast erosion can often be remedied, but deep-sea erosion cannot.

(*i*) Removal of Material from the Shore.

On some parts of our coast limestone and other stone has been allowed to be removed from the foreshore; this practice has not yet entirely stopped. In one year as much as 10,000 tons of limestone were taken from the cliffs and ledges near Lyme and exported to Hull. Many examples might be given as to the acceleration of erosion due to the removal from the foreshore of sand and shingle.

(*j*) Obstructions on a Shore Causing Erosion.

It is a very unwise thing to place upon the shore any obstruction with a view to preventing erosion, or with the object of breaking up the waves; many such obstructions may be found around our coasts. At Preston (near Weymouth) a long line of heavy rocks were deposited upon the sea bed at L.W.M., the result being that they were so detrimental that they had eventually to be blasted away. Another example of this practice is to be found at Bridlington, Yorkshire; the sea wall (see Fig. 4) protecting the spa was built a few feet shorewards of the ruins of a previous sea wall, and the result has been that scouring action has taken place. The remains of old groynes and breakwaters are often left on the foreshore. At Troon, in Ayrshire, where the author carried out a sea defence scheme, he found it necessary to build a

* "The Evolution of a Coast Line," by William Ashton.

† "The Evolution of a Coast Line," by William Ashton.

* "Geological Journal," Vol. LX., p. 101.

FIG. 4.—Erosion caused by obstructions at Bridlington (South Shore.)

new sea wall some distance seaward of the old one, in order to avoid the huge rocks which stood up above the foreshore (see Fig. 5).

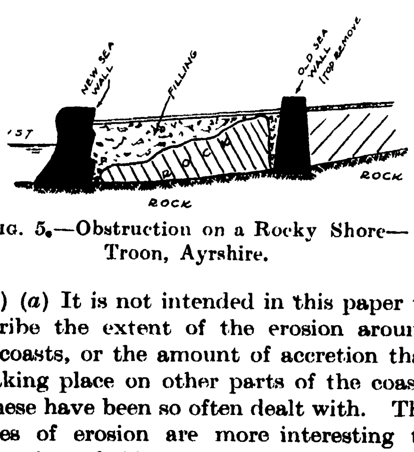


FIG. 5.—Obstruction on a Rocky Shore—Troon, Ayrshire.

(3) (*a*) It is not intended in this paper to describe the extent of the erosion around our coasts, or the amount of accretion that is taking place on other parts of the coast, as these have been so often dealt with. The causes of erosion are more interesting to the readers of this paper, and the suggested best methods of remedying it.

(*a*) PROTECTION DEVICES.

Many devices for the prevention of erosion have been introduced, but most of these have proved a failure. Floating breakwaters anchored to the shore, large rocks, and in some cases huge blocks of concrete, specially arranged on the foreshore (below and above L.W.O.S.T.), with a view to breaking the force of the waves, have been tried with the object of protecting the shore, but most of these have created a scour and have done much damage instead of good. Rows of piles have sometimes been driven parallel with the shore and a few feet seaward of the cliffs or sea wall, but most of these have been quite unsuccessful.

Dr. Owens suggests that shore protection works might be divided into active and passive types; the former comprising groynes and such structures as attempt to do something more than merely resist attack; the latter, including sea walls and embankments, which only attempt to substitute a harder and more durable material for a softer. Following this course, we will next discuss "groynes."

METHODS OF PREVENTION OF EROSION.

(*b*) *Groynes.* — Some engineers avoid the construction of groynes in a scheme of sea defence, and only adopt them as a last resource. The author's experience has taught him that the erection of a sea wall, or other form of sea defence running parallel with the coast, is of itself usually insufficient and often increases the erosion on the shore, and, for the purpose of collecting and retaining beach or sand in front of a sea wall, and, incidentally, in protecting the wall against scour by the sea, it is necessary to construct in many (but by no means all) cases a system of groynes. On the other

hand, groynes without a sea wall or other form of sea defence at, say, the foot of an easily-eroded cliff, will generally be of little use.

Great care should be taken in the choice of the type of groyne to be erected, and of the material of which it is to be constructed; reinforced-concrete, timber, mass-concrete or concrete blocks are in general use. It must be remembered that what would be a great success on one part of our coast might be a failure on another part.

Then with regard to the *height* of groynes, serious results and great erosion have been caused by constructing very high groynes where low ones should have been introduced. On the South Coast the high groyne has been largely adopted, and the author does not at all favour its use. (See Fig. 6).

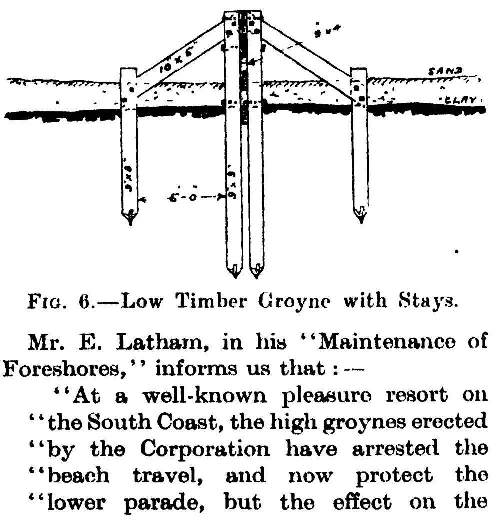


FIG. 6.—Low Timber Groyne with Stays.

Mr. E. Latham, in his "Maintenance of Foreshores," informs us that:—

"At a well-known pleasure resort on "the South Coast, the high groynes erected "by the Corporation have arrested the "beach travel, and now protect the "lower parade, but the effect on the "sewage outfall situated on an adjoining "promonotory within the boundaries of "the borough has been disastrous, the "outfall works having been denuded "of their original protective shingle "formation."*

TYPES OF GROYNES.

Timber Groynes.—No standard type of groyne can be introduced which would be suitable for any part of our coast.

Where there is an abundant quantity of shingle on the foreshore, and the shore is rocky, concrete groynes (if not high) are suitable; these should be stepped down to suit the gradient of the foreshore and keyed into the rock. On a flat foreshore where sand overlies say, clay, low timber groynes extending to L.W.O.S.T., are useful; high timber groynes should not be introduced, and the type of timber groyne the author has sometimes adopted and which has proved very satisfactory is shown in Fig. 6.

This type of groyne may be described thus:—It consists of a double row of 9in. by 9in. piles with 9in. by 9in. anchor piles. The former are 14 feet long, the latter 8 feet, penetrating into the clay to a depth of 6 feet. The stays are 10in. by 5in. The planking is 11in. by 4in., and is inserted between the pairs of piles, which are shod with 28lb. shoes. The stays are only inserted at every third set of piles, and the main piles are pitched 7 feet apart, beginning and ending with a set of stays. On some parts of our coasts, where wave action is not severe, this type of groyne can be used minus the stays, but it is wise in most cases to insert them. Groynes of this type should be carried to L.W.O.S.T. (See Fig. 7).

REINFORCED-CONCRETE AND MASS-CONCRETE GROYNES.

The disadvantage of using timber in the construction of groynes is that the material is not durable; this, however, in the author's opinion, has been somewhat exaggerated in this country: for example, 20 years ago when Borough Engineer of Bridlington, the author constructed a system of low timber groynes (17), on the north side of the harbour, somewhat resembling the "Case" system; these have proved very successful, and are in as good a condition to-day as when put down. They consist of 9in. by 9in. piles (Pitch pine) placed in pairs with 11in. by 4in. planking fitting in between the piles. The piles were 14 feet long and placed 7ft. 6in. apart. They penetrated into the clay to a depth of 8 feet, and were so arranged that the planking could be raised or lowered as the beach accumulated. When the author inspected these groynes in September last most of the planking was entirely buried in the sand, and only the tops of many of the piles could be seen. The good condition of these groynes is due, no doubt, to the fact that they were constructed on a sandy foreshore, and that there was little attrition of shingle as there would have been on a foreshore of beach.

It must be admitted that on some parts of our coasts where there is shingle, and attrition is very great, timber suffers severely

* "Maintenance of Foreshores," by Ernest Latham, M.Inst.C.E.

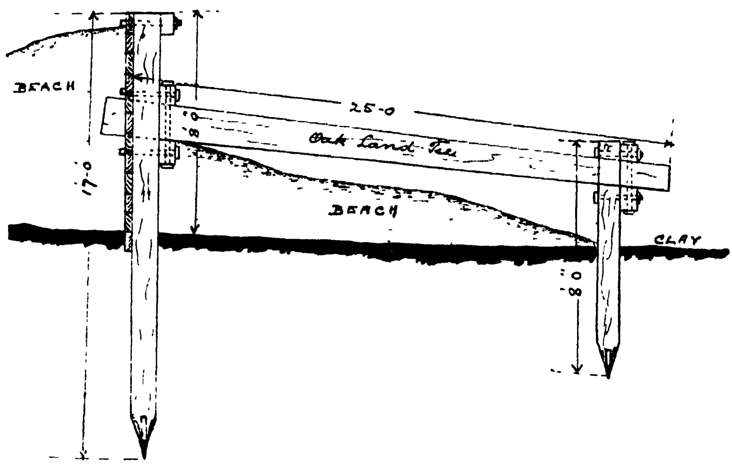


FIG 7.—High Timber Groyne

and groynes of a more durable character should be introduced ; to meet this demand the "Owens-Case Reinforced-Concrete Groyne" has been constructed on various parts of our coasts, and in most cases has proved very successful. On a sandy shore they are quite satisfactory, but sometimes on a shingle shore where wave action is most severe (as on the South Coast), the attrition of pebbles is considerable, and a slight wearing of the edges of the piles is visible. It is difficult to prevent this entirely, but this defect is being overcome very largely in the Owens and Case groynes now being constructed. Groynes of this type can be constructed at a fairly reasonable sum where there is an abundance of shingle as aggregate for the concrete.

In constructing groynes of this type great care should be exercised in the driving of the piles, as, unless they are very accurately spaced it is difficult to insert the R.C. slabs.

Heavy mass concrete groynes, or concrete groynes faced with concrete-blocks, or basalt, or other stone, and extending from a sea wall to the foot of, say, a steep beach, are useful sometimes (especially on a rocky shore), or where wave action is most severe, as, say, on the South Coast at Hastings, but these should be kept as low as possible, and the author recommends the construction from the bottom of the beach to L.W.O.T. of a low timber groyne. It is very doubtful if any other type of groyne than the concrete or concrete-block type would have been suitable at Hastings, where the range of the tides is so great (25 feet), and wave action during a South-Westerly gale so severe. Timber groynes on the beach slope would have been of little use, and even reinforced concrete groynes would not have been so suitable as concrete-block faced low groynes. At Brighton, the Owens Case R.C. groyne has been installed, and seems to be giving every satisfaction, regardless of the fact that the beach material contains so many sharp flints.

With regard to very high timber groynes, as in use at Eastbourne, these are not only unsightly and dangerous to young children using the shore, but are of little use as "groynes," and have occasionally to be scuttled in consequence of the large accumulation of shingle on the windward side.

It is a useful practice when designing timber groynes, so to arrange them as to allow two bays near H.W.O.S.T. to be adjustable, so that the planks above the shore level can be removed easily, and the impounded shingle in the angle formed by the groyne and sea wall carried through the opening into the next bay where the shore is probably denuded. A good example of this may be seen at Clacton.

General Notes on Groynes.

The main use of groynes is to arrest the drift of material ; they cannot of themselves afford protection to the coast, neither should they be constructed as breakwaters to modify wave action, except in unusual cases.

No definite rule can be applied as to the distance apart that groynes should be placed. As a rule, it is wise to carry long low timber groynes to L.W.O.S.T., but this cannnot always be done.

Direct on-shore gales usually denude the beach, but groynes will not prevent this.

On shingle beaches the movement of material is greater than on sandy beaches ; a banking up of material on the windward side of the groyne will, therefore, be greater where there is shingle.

The running out of an open jetty some distance seawards of L.W.O.S.T. usually causes an accumulation of sand or shingle on the windward side of the jetty. At Ymuiden harbour, for example, this has occurred.

It is sometimes possible for a single groyne to protect quite a long length of coast ; on the other hand, if the groyne is a "high" one, and is carried to L.W.O.S.T., it may mean that a considerable banking up of shingle will occur on the windward side, and the beach be denuded on the lee side for perhaps a mile. The author's advice was sought in a case like this recently.

Groynes should be sloped off to the angle of the foreshore, or stepped, and, speaking generally, they should not be higher than, say, three feet above the foreshore. The best direction for groynes is slightly in the direction of the heaviest seas.

Faggots.—Probably the cheapest form of sea defence to be found around our coasts, are faggots, inserted in the beach usually at about H.W.O.S.T., for the purpose of holding the beach or sand ; this is usually fairly successful if carefully watched, and immediately repaired should a breach occur. It is, nevertheless, only of a very temporary character.

Good examples of this form of defence may be seen on the coast line between Pevensey and Bexhill, and in the case of a sandy shore, at Skegness.

(*To be continued*)

THE BUILDING-MATERIALS INDUSTRY IN CZECHOSLOVAKIA.

The building materials industry in Czechoslovakia occupies a very prominent position among the industries of the country. Its importance is due to the rich deposits of kaolin, clay, limestone and coal with which Czechoslovakia is naturally endowed.

Owing to the favourable supply of raw materials the brick industry is one of the oldest in the country. There are more than 700 brick works, the most extensive being that of Hodonin, which produces 60 million bricks or tiles per annum. The number of workmen employed in the brick industry amounts to 80,000 and the annual output is about 2 billion bricks and 200 million tiles.

Kaolin constitutes one of the most important factors in the development of the paper, porcelain, and pottery industries. The largest kaolin deposits are located in the districts of Plzen, Podborany, Karlovy Vary and Western Slovakia. The annual capacity of output amounts to more than 20,000 waggons, of which 80 per cent. is exported. The bulk of this exported kaolin, about 75 per cent. in all, is purchased by Germany, where this product is indispensable. The remainder is distributed between Austria, Poland, Jugoslavia, Hungary, Switzerland, France and Italy Czechoslovakia contains 30 large kaolin mines, and several hundred smaller ones. English kaolin is the most considerable competitor of the Czechoslovak product.

Porcelain is produced in 70 factories, especially in the kaolin districts of Western Czechoslovakia. The annual output exceeds 3,000 waggons, 70 per cent. of which are exported. The bulk of the luxury porcelain is sent to the United States, Great Britain and Germany ; white porcelain to America, India, Italy and Jugoslavia; technical porclain to America, Italy, Switzerland, England, Germany and Rumania. The most extensive customers for these goods are America and the Balkan countries.

The most important centres for the manufacture of fireproof goods are located in the West of Bohemia, Prague, Southern Bohemia, Central Moravia, Lower Slovakia, and Carpathian Ruthenia. The output of the magnesite mines of Lower Slovakia is largely exported, for the most part to America. Czechoslovakia produces annually 40,000 waggons of fire-proof bricks which are exported to all European countries, as well as to overseas countries.

The annual output of pottery amounts to 2,000 waggons. The export trade is with the Balkan countries, Poland, France, the Netherlands, Scandinavia and South America, competition being carried on in this branch with England and Germany. There are 60 factories producing an annual total of 5,500 waggons of stone and chemical piping. The export trade, which comprises 4,100 waggons, is with southern eastern and northern Europe, its most considerable competitor being that of Germany.

The Czechoslovak flagstone industry is carried on in 12 factories with an annual capacity of 9,000 waggons. In 1920 the total amount exported was 7,728 waggons, although the factories were not working at their full capacity.

Another export product is artificial Portland Cement, obtained from 12 factories with a total annual capacity of 50,000 waggons. The export trade is with Germany and Austria.

The annual production of limestone amounts to 90,000 waggons, 10 per cent. of which is exported. The chemically purest limestone is found at Koneprus, near Beroun. The hydraulic

limestone of Prague used to be exported largely to France, Italy and England.

Among the natural building-stones there are numerous types of granite. Special reference may be made to those of Benesov, Jindrichuv Hradec, Petrograd, Blatna, Skutec, Hlinsko and Silesia.

Sandstone rocks are found at Horice, Decin and elsewhere. Czechoslovak marble is being more and more exported. The largest red and grey marble quarries are at Slivenec, near Prague. White marble is found in Silesia. The export of natural building-stone in 1920 amounted to 1,800 waggons, the countries to which it was sent being Germany, Hungary, Poland and Jugoslavia.

The Czechoslovak building-materials industry forms a group of the Federation of Czechoslovak Industrialists. The problems affecting this industry are studied from a scientific and practical point of view at the Prague and Brno polytechnic schools and the Masaryk Academy. There are also special schools at Bechyn, Znojmo and Teplice for pottery, at Plzen for brickmaking, and at Horice and Supinkovice for stone-cutting respectively.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday, May 31 (at 3 p.m.)—Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Problem of Provincial Galleries and Art Museums, with special reference to Manchester." Sir Charles J. Holmes, D.Litt., F.S.A., Director of the National Gallery, in the chair.

Indian Section.

Friday, June 23 (at 4.30 p.m.)—F. W. Woods, C.I.E., late Chief Engineer, Irrigation Department, Punjab, "Irrigation Enterprise in India." Lord Lamington, G.C.M.G., G.C.I.E., Governor of Bombay, 1903-7, in the chair.

Dominions and Colonies Section.

Friday, June 9, at 4.30 p.m.—Major Sir Humphrey Leggett, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)." Right Hon. Sir Frederick D. Lugard, G.C.M.G., C.B., D.S.O., in the chair.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Monday, May 29..British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. W. Harvey, "Colour in Architecture."

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. J. E. H. Thomson, "The Readers for whom the First Gospel was Written."

Geographical Society, 135, New Bond Street, W., 5.30 p.m. Anniversary Meeting. Presidential Address and Presentation of Medals.

University of London, University College, Gower Street, W.C., 5 p.m. Mr. A. T. Walmisley, "Groynes and Sea Defence Works."

5.30 p.m. Prof. T. Borenius, "Past History of Art Teaching."

Chemical Industry, at the Institute of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Sir George Beilby, "The Structure of Coke: its Origin and Development."

Tuesday, May 30..Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. E. J. Bedford, "Wild Flowers."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. Maurice Thiéry, "Le Théatre d'Amour, Georges de Porto Riche."

Royal Institution, Albemarle Street, W., 3 p.m. Sir Percy Sykes, "Twenty-five Years' Travel in Persia." (Lecture I.)

University of London, King's College, Strand, W.C., 5.30 p.m. Dr. D. Subotic, "Influence of Geography on the Economic Conditions of Jugo-Slavia. (Lecture I.)

5.30 p.m. Mr. C. E. M. Joad, "Vitalism Restated." Lecture I: "The Reduction of Ethics in Psychology."

Wednesday, May 31. People's League of Health, at the Royal Society of Arts, John Street, Adelphi, W.C., 6 p.m. Mr. R. R. Hyde, "The Country's Needs and how to meet them through Health in Relation to Industry and Commerce."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 3.30 p.m. Anniversary Meeting.

University of London, King's College, Strand, W.C., 5 p.m. Dr. A. Harker, "Geology." (Lecture III.)

Thursday, June 1. Royal Institution, Albemarle Street, W., 3 p.m. Very Rev. Dean Inge, "Theocracy." (Lecture II.)

University of London, King's College, Strand, W.C., 5.30 p.m. Rev. Percy Dearmer, "Central and North Italian Painters of the Fifteenth Century." (Lecture V).

At King's College for Women, Campden Hill Road, W., 4.30 p.m. Prof. V. H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture VI.)

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. "Hooker Lecture by Prof. Seward."

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (a) Messrs. J. S. Buck and I. M. Heilbron, "The re-activity of Doubly-Conjugated Unsaturated Ketones." (Part III.: "Unsymmetrical Hydroxy- and Methoxy-derivatives.") (b) "Phenopyryllium Salts of Distyryl Ketones." (Part I.).

Engineers, Junior Institution of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 7.30 p.m. "Canet" Lecture by Sir Eric Geddes.

Friday, June 2..Royal Institution, Albemarle Street, W., 9 p.m. Hon. Maurice Baring, "Gilbert and Sullivan."

University of London, King's College, Strand, W.C., 5.30 p.m. Mrs. Rosa Newmarch, "The National Opera of Czecho-Slovakia." (Lecture I.)

Philological Society, University College, Gower Street, W.C., 8 p.m. Dr. Henry Bradley, "Dictionary Evening."

Saturday, June 3..Royal Institution, Albemarle Street. W., 3 p.m. Sir Hugh Allen, "Early Keyboard Music." (Lecture II.)

Journal of the Royal Society of Arts.

No. 3,628 VOL. LXX.

FRIDAY, JUNE 2, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

FRIDAY, JUNE 9th, at 4.30 p.m. (Dominions and Colonies Section.) MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)." THE RIGHT HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., in the Chair.

TWENTY-THIRD ORDINARY MEETING.

WEDNESDAY, MAY 24th, 1922; SIR GEORGE T. BEILBY, D.Sc., LL.D., F.R.S., Director of Fuel Research, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Beall, F. F., Detroit, Michigan, U.S.A.
Doyle, William, B.A., Loughborough.
Javeri, Ratilal C., London.
Kilachand, T., London.
Mukherjee, Tarak Nath, Howrah, Bengal, India.
Palairet, Charles R., Indore State, India.
Small, Frank S., B.Sc., New York City, U.S.A.

The following candidates were balloted for and duly elected Fellows of the Society:—

Howgrave, Walter, Addiscombe, Surrey.
Marshall, Henry, M.S.A., Calcutta, India.
Muirhead, Alexander, C.I.E., London.
Pearson, Nels August, Rancagua, Chile.

A paper on "The Natural Power Resources of Ireland (Coal, Peat, Water Power)" was read by MR. GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland.

The paper and discussion will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

FRIDAY, MAY 26th, 1922; THE RIGHT HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, in the Chair.

The Sir George Birdwood Memorial Lecture on "Indian Painting and Muhammadan Culture," was delivered by SIR THOMAS W. ARNOLD, C.I.E., D.Litt., M.A., Professor of Arabic, School of Oriental Languages.

The lecture will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING

WEDNESDAY, APRIL 5TH, 1922.

LORD HEADLEY, M.INST.C.E.I., in the chair.

COAST EROSION AND ITS PREVENTION.

BY PROFESSOR E. R. MATTHEWS, Assoc.M.Int.C.E., F.R.S. (Ed.), F.G.S.

(*Continued from page* 489.)

(c) SEA WALLS.

The author has already said that groynes are not intended to prevent erosion so much as stopping the drift on a shore. To protect low-lying land from the inroads of the sea, or to prevent erosion of cliffs, it is necessary, in most cases, to construct a permanent form of sea defence running parallel with the shore; this is usually a sea wall, or an embankment; a system of groynes is, in most cases, required as well. Space in this paper cannot be found for a description of the various types of sea walls met with around our coasts; they vary considerably on different parts of our coasts, some being step-faced, as at Bridlington (Royal Princes Parade), others curved-faced, as at Scarborough (Marine Drive), a few sloping, as on many parts, particularly the South Coast, and a number vertical. The merits and demerits of each of these types of walls have been the subject of much discussion.

Then, as to the materials of which they are constructed. Some are stone-faced (including basalt), others are faced with concrete blocks or flints, while quite a number are of mass concrete.

There are also around our coasts a few examples of reinforced-concrete sea walls.

With regard to "vertical" and "sloping" walls, these are most useful as harbour walls, and especially the vertical wall, but they are not so serviceable for coast protection.

A comparison between harbour walls and those intended to protect the coast is scarcely fair, because a sea-wall has to act as a retaining wall as well as resist the force of storm waves. The author has recently designed a sea-wall which is surcharged by a cliff 80 feet high, and the thrust on the wall is considerable (see Fig. 8). In the case of a breakwater running out from the shore there is equal water pressure on both sides of it, except during a storm when the waves strike the wall with tremendous force.

NOTES IN GENERAL ON SEA WALLS.

Three forces act on a sea wall :—

(1) Earth pressure at the back of the wall.

(2) The force due to the momentum of a wave moving with great velocity and being suddenly stopped.

(3) The statical pressure due to the head of water brought against the wall by the upward projection of the waves.

Mr. Wheeler suggests that "the strongest part of the wall should be at the point where the wave changes from the horizontal to the vertical position."*

It is very necessary that whatever the profile of the wall may be a heavy projecting cornice should be inserted to throw back the wave, and so prevent it from leaping the wall, and falling heavily upon the road or promenade at the back; much damage is often done in this way. The author has often seen concrete on a promenade broken up like pie-crust, and on one occasion he saw the whole road at the back of a sea wall drop 3 or 4 feet after a violent storm. Undoubtedly the best form of wall is the stepped-face with concrete backing where stone can be obtained at a reasonable cost. Walls of this type were con-

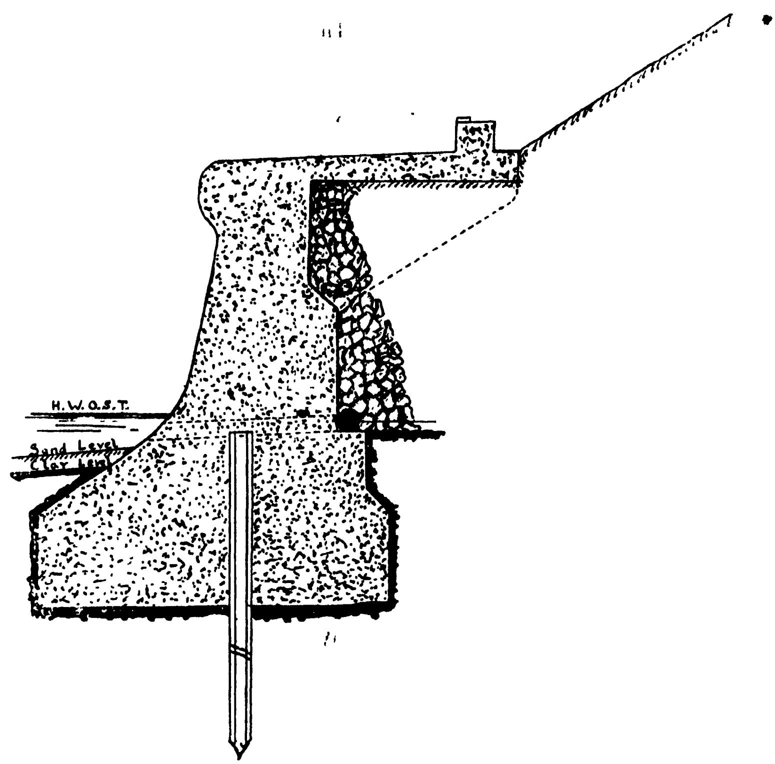


FIG. 8.—Mass-Concrete Sea Wall (where stone facing or concrete-block facing is too expensive).

* "The Sea Coast," by W. H. Wheeler, M.Inst.C.E.

structed by the author at Bridlington a few years ago; they need no description; they have answered their purposes well, and their chief advantage is that the stepped-face quite breaks up the wave as it strikes the wall; the sea falling down the steps with much less velocity than in the case of the smooth-faced wall, little scour at the base of the wall occurs.

It is quite possible to face the wall with concrete blocks and step it in a similar way.

FAILURES OF SEA WALLS, WHY?

A large proportion of the failures of sea walls is due to:—

(a) The sea getting at the back of the wall, often through displacement of a portion of the surface of the promenade, or by flooding during abnormal tides.
(b) No projecting cornice having been inserted to throw back the wave.
(c) The sea undermining the foundations through these not being carried deep enough.
(d) The wall being too low, or too light in section.

THE ISLE OF WIGHT PERIL.

General J. B. Seely, a few months ago, drew attention in the papers to the fact that there was a likelihood that in course of time, the Island might be cut in two by the inroads of the sea, and the author agrees with him. The part of the Island where the sea might perform this is Freshwater, which is inadequately protected. All that the sea would have to do would be to surmount a shingle beach protected for a part of its length by a concrete esplanade about 8 feet high.

Behind this wall, and only about 50 yards from it, is the source of the Yar which is only a foot or two above sea level.

Should an exceptionally high tide occur at Spring tides, during a violent south-westerly gale, the sea might surmount the low barrier, and run down the valley of the Yar to the Solent at Yarmouth, thus completing the severance.

Most of the esplanade at Freshwater is now in ruins as the result of the heavy seas this winter, and it has been decided to demolish the remaining portion, and to build new sea defence works. It is hoped that the Government will contribute substantially to the cost of these works, and the Royal National Lifeboat Institution, the author understands, has promised to bear part of the cost if a Lifeboat station can be established there: the remainder of the cost will no doubt be met by the Local Authority.

SALT MARSHES.

The growth of salt marshes in this country occurs almost always in river estuaries, and at the mouth of rivers which are sheltered from wave action. They are formed in the following manner:—

The upper soil of which the marsh is composed is deposited about the time of H.W.S.T. Up to the level of H.W.N.T. sand and silt only are deposited, the fine warp in which the marine grasses of the salt marshes grow is never deposited below the level of H.W.N.T.

In England large areas of marshes have been formed in the river estuaries from alluvial matter brought down in suspension. They have been reclaimed from the sea by embankments, and some form valuable agricultural land.

AMERICAN EXAMPLE.

On the East Coast of the United States, the largest area of salt marshes in the world is to be found; they cover an area of hundreds of square miles, and most of this area is covered by only one or two feet at high water. Mr. Shaler (in his "Sea and Land") estimates that "along the coast South of New York, there are not far from two million acres of marshes fit for reclamation, and which, owing to the small rise of the tide (which does not exceed from 4 to 5 feet) and in consequence of the banks already formed by the sand along nearly the whole length, could be enclosed at a comparatively small expense."*

One of the greatest reclamation schemes brought forward in England was for the reclamation of 150,000 acres of land in the Wash. This scheme received the sanction of the Government, and was supported by a number of eminent engineers, but was never carried out, although numerous much smaller schemes were subsequently carried out. Much of the land included in the big scheme was, however, quite unfit for reclamation.

COAST EROSION COMMISSION REPORT.

In 1912 the Report of the Commissioners was published, and many were suprised to find that the land was giving back more

* "Sea and Land," by N. S. Shaler (Smith, Elder & Co.).

ground to the seaboard than was taken away by erosion; but, the author would point out, nearly all of this occurs in estuaries, and most of it is sediment brought down by the rivers and deposited in estuaries, and cannot be compared with the valuable agricultural land washed away. Many thousands of acres of this reclaimed land is only marsh land of little, if any, value. Then it is of little satisfaction to a land owner on say, the East Coast, to know that the land which he has lost has re-appeared in some estuary.

The Commission admitted that the gains were in tidal estuaries, but the losses were on the open coast.

The largest gains around our coasts are at Southport, in Morecambe Bay; and in the Wash. Between Preston and Southport 7,400 acres have been reclaimed within the past century. On the east coast the loss is very much more than the gain if the accumulations in the Wash and Humber are disregarded.

In June 1912 it was stated in Parliament that a Bill was in preparation dealing with the Coast Erosion Commission's Report, but so far nothing more has been heard of this.

COMMUNICATION FROM MINISTRY OF AGRICULTURE AND FISHERIES.

The author wrote a few months ago (at the beginning of this winter) to the above Ministry, suggesting that the time was opportune, owing to the large number of unemployed, for the Government to take in hand the protection from the inroads of the sea of certain parts of our coasts where erosion was most serious and that this be done on a contributory basis. The basis that the author suggested was that on a part of the coast where erosion was severe (as on the Holderness Coast of Yorkshire) (See Fig. 9), and where the land was only poor quality agricultural land, and the owner was not able to afford to protect it, not even by constructing a system of groynes, the Government should carry out the necessary protection works on the following financial arrangement:—

That the landowner should contribute one-third of the cost of protection, the Rural District Council and the County Council (combined), say, one-third of the cost, and the Government one-third. The author believes that such an arrangement would prove satisfactory.

The reply received was to the effect that the Ministry had recently had this question under consideration, but they had decided to take no action, as the problem of housing and feeding large numbers of men at these isolated parts of our coast, especially during the winter months, presented considerable difficulty. They also

FIG. 9.—Erosion on Holderness Coast of Yorkshire (11 feet per annum).

reminded the author that the Royal Commission had decided that works for prevention of coast erosion must be regarded as a local, and not a national matter. Under these circumstances they intended to take no action in the matter.

The writer is indebted to the authors of the various works referred to in this paper, for the quotations he has made from their books, and to Mr. T. Henry Tyson, the Borough Engineer of Portland for much valuable information regarding the Chesil Beach.

DISCUSSION.

THE CHAIRMAN (Lord Headley), in opening the discussion, said in sea work there was great difficulty in getting sufficient data to enable one satisfactorily to cope with questions which arose. The first thing was to interview the oldest inhabitant, and find out what had been the highest tide within living memory in the particular locality. That information was not all that was required, because at any time there might be a very difficult combination of an exceptionally high tide, accompanied by a most disastrous wind. One of the greatest difficulties was that often a sufficiently large amount of money could not be spent because the clients could not afford to pay it. Too light a protection must not be used, because if the combination to which he had referred produced bad results the engineer would be blamed. At a place on the Southern Coast of Ireland he was called in, and after examination suggested a simple plan for the adoption of low groynes, and the cost was very little—£1,500 or £1,000. The authorities said: "We are very sorry we cannot do that; we will give you £200 to put in one groyne, and if that is a success, we will let you go on." He replied: "You will only get one result by putting in one groyne, and that may be disaster, because you will find that the sea will make an inroad at some portion of the coast close to that groyne. You must treat the shore as an entire piece, or else let it alone altogether." It was a legal maxim that a man must not, in order to protect himself or his property, resort to devices which injured his neighbour's property. That was a most important matter in regard to coast protection. It was impossible to erect an obstruction, or sea wall, or jetty, without altering the conditions along the coast line. All the currents were altered, and the effect could not be foretold. Engineers of the greatest eminence had been considering the question of extending the Admiralty Pier at Dover for about 150 years, and the result of all their work had been that Dover Harbour was not satisfactory. Sailors had said to him: "You cannot get into Dover Harbour if it is rough weather." He pointed out that the object of the harbour was protection in rough weather. They said: "Never mind, you often cannot get into it if it is rough weather. It was supposed to do away with the silt, but opposite the Prince of Wales's Pier, you cannot moor vessels, as formerly." It was almost impossible for a man to say what the result would be of putting in any devices such as a harbour or a sea wall or a jetty. He was almost the first engineer to call attention to the topic of deep sea erosion, about which there were very different opinions amongst eminent engineers. On the Holderness Coast, in Yorkshire, there was a very large amount of stuff travelling all the way round in suspension. The cliffs between Flamborough Head and Spurn Point had been wasting about four feet a year for years. He had calculated how many hundreds of thousands of cubic yards must have been washed away and that stuff must go somewhere. Some of it went into the deep water, but the great portion was either laid along the bottom and travelled away, or was carried in suspension and deposited at different depths, from there, to be moved along and carried further down. The trend on the Holderness Coast was North and South, and he contended that the stuff was deposited across the mouth of the Humber, and, he believed, as far as the Wash. He had had experience on many coasts, and maintained that whenever there was a great erosion going on, and at the same time, an accretion or deposit of sand banks not far distant the probability was that the two were connected in some way, and how could they be connected except by the fact that what came from the one place went to the other? Skegness and the Wash were silting up very rapidly, and he assumed that the stuff that was taken from Holderness Coast, in Yorkshire, was carried to places where the accretion was observable. This was going on at the rate of about an inch every year, and two hundred years hence, or less, he believed that the Wash would be part of England, and 100,000 acres would be added to the area of this country. The Government should be asked to spend a little money in making sure of that. Many thousands of tons of coloured material, not indigenous to that coast at all, might be put down right into the sea along the coast. After a year or so, considerable portions of the sand on the shore at Skegness and the Wash should be microscopically examined, and the microscope would probably reveal the presence of this coloured material, and in that way give proof positive that the stuff was washed down. If it were not, the theory would be upset.

SIR GEORGE BUCHANAN, K.C.I.E., M.Inst.C.E., said that in Madras, which Professor Matthews had mentioned as a glaring instance of coast erosion, when there was a very bad storm the ships in the harbour at once weighed anchor

and went to sea, because the harbour was unsafe.

Mr. W. Whitaker, F.R.S., said they had heard of the difficulties which engineers had to deal with in contending against the inroads of the sea, and he could agree with the previous speakers in that matter, as he had seen how work at one place affected work at other places and caused damage. He had known cases where (say), £100 had been saved in one place, and damage to the extent of £1,000 had been caused in another. It was necessary to discover what was going on along the coast. It was a matter, not of isolated work, but of concerted work over a large area It was often of no use that one individual or local authority should do work to protect itself, because the work must be extended far and wide. The southern end of Lowestoft was going rapidly as the result of what had been left undone by a neighbouring authority over which Lowestoft had no control Lowestoft could do nothing to defend itself. The whole piece should be treated as one, regardless of who were the local authorities, and until concerted action of that kind was set up, nothing very great and important in regard to the matter of coast-defence would be done. There were places where it did not pay to defend the coast There might be a long stretch of coast where the land was of little value, and it would cost a hundred times as much to save that coast as the freehold value of the land.

There was one thing that could be done at once, and that was that the taking away of shingle and sand on the sea shore should be generally prohibited. Nature had given a shingle defence, and that should not be allowed to be removed as a rule, because its removal was generally bound to result in damage elsewhere He did not say there was no shingle in the world that could not be taken away without damage, and one instance was Dungeness, where the shingle extended a mile inland. It did not matter what was done with that; there was enough shingle there to satisfy the demands of the whole kingdom On the shore nothing should be done, except where it could be shown to be harmless. In all such work, and in engineering works generally, nothing should be done to oppose nature, but rather to lead her.

Mr. C. S. Meik, M.Inst.C.E., said there was no branch of engineering that was open to more controversy than coast erosion. Engineers differed very seriously on all matters in connection with it. The drift of the East Coast was north to south, and on the South Coast from west to east, and it was agreed that the drift was with the flood tide. Those were the only two principles which were universally accepted with regard to coast erosion. Every district must be treated on its own merits, and he did not think an engineer was fully qualified to deal with the case of coast erosion unless he was fully acquainted with the facts and knew the locality; he was simply wasting his client's money if he attempted work when he did not know the locality. Reference had been made to Lowestoft, and it was stated that the erosion to the southward was caused by the construction of a harbour there. The harbour was only constructed in 1835, and before that the coast line was unbroken, so that there was free travel for the shingle along that coast. There had always been a ness at Lowestoft, and that, at one time, extended for three-quarters of a mile from the base of the cliffs. Since the harbour was made, the ness had decreased, and erosion had gone on at a great rate, the high water line being now over one thousand feet further in shore than when the harbour was made. The erosion at Lowestoft had been going on for generations. Mr. Whitaker had referred to the travel of shingle, but what was to be done when the shingle went into the harbour at Lowestoft? It had to be dredged out of the harbour, and that was why the bulk of the shingle was taken away when it ought to go to the South. He agreed with all that had been said about the travelling of shingle on the East Coast. The larger material crossed harbour mouths or other obstructions, a great deal lodged in the Wash, and some of it went to form the sand banks of the coast. Undoubtedly the shoals in the Wash had been formed by material coming down the Yorkshire and Lincolnshire coasts. On the question of deep sea erosion, he did not believe anything such as had been described took place. He could not see how it could happen. The bed of the ocean had obtained equilibrium, and the Admiralty charts did not show any erosion.

The Chairman asked how Mr. Meik accounted for the fact that there were five fathoms of water in places where it was once dry land. Up to a depth of 15 or 20 fathoms, there might be a certain amount of erosion.

Mr. Meik said the only other point he would refer to was the erosion on the Norfolk Coast. He thought that during the last year there had been more erosion than he had ever seen, and if any member of the Society wanted to spend a pleasant fortnight, he should walk along the coast of Norfolk. He would see erosion going on there at a tremendous rate, especially two or three miles north of Yarmouth. Within six months, as much as one hundred feet of coast had gone, and in one place, at Caistor, there was a hotel which was inside the sea wall, and was now on the verge of dissolution.

Major Arthur J. Martin said there was great danger in putting up coast defence, if the work was afterwards neglected. He was

dealing, last summer, with a sea wall protection with groynes, which had sunk, with the result that there was a current undermining the wall. He expressed, on behalf of the audience generally, their indebtedness to Professor Matthews for his paper, and the wonderful series of pictures which he had thrown on the screen, and particularly the storm pictures. How they were got was simply a marvel. He had had the greatest difficulty in taking photographs of very small seas indeed, and the man who took the photographs at Hastings and elsewhere must have been a genius and something of a hero.

MR. C. H. COLSON, O.B.E., M.Inst.C.E. (Civil Engineer in Chief's Department, Admiralty), said that he considered that the formation of Chesil Beach was due to the joint action of the prevalent south-west winds which drifted the shingle to the eastward, and at the same time washed the finer portion of the shingle round the Bill of Portland into Weymouth Bay and the tidal currents setting up the Channel which split at the Bill of Portland, one section continuing up the Channel and the other being diverted in a North-western direction along the shore to Abbotsbury, which screened the shingle and washed its finer portions back towards the westward. Practically the same action was happening at every groyne and every headland up the coast. Professor Matthews had said that the littoral drift changed at Dungeness, and that this change was the reason for the formation of Dungeness. Mr Colson rather differed from him there. He knew the whole coast from Shoreham to Dover, and on that section the drift of the shingle over the whole length was from west to east, changing at Deal from south to north up to Ramsgate. Wherever a groyne or pier was put up on that section of the coast, it collected material coming from the westward, while to the east of such groyne or pier, finer material would be found coupled with an erosion of the coast line due to the fact that the groyne or pier had cut off the supply of shingle coming from the westward. For instance, at Hastings, the groynes were filled with shingle, while on their lee-side was sand. No doubt, at the bottom there was sand, and the heavier shingle was raised by the waves and thrown on the beach. For some reason or other, the supply of shingle over the whole coast line seemed to have been less in recent years, and the fact that so many people were now erecting groynes tended to restrict the movement of the shingle to a much greater extent than had obtained in the past. At Kingsdown, for instance, within his knowledge, the shingle had been cleared away from Hope Point as far as the butts of the Admiralty Rifle Range almost entirely, while between the butts and Kingsdown large portions of the shingle had been removed, and it appeared that in a comparatively small number of years, unless something very drastic was done, the houses which now stood on the beach at Kingsdown would have their foundations washed away. Unless there was a sufficient supply of shingle being washed along the shore to fill them, it was no use constructing groynes. Mr. Colson wished to draw attention to an interesting physical characteristic near Sandwich. At the present time, the River Stour ran between the Isle of Thanet and the mainland close to the Thanet shore to within a short distance of Ramsgate, where it turned and ran towards Sandwich. At Sandwich, the river turned back on its course and eventually discharged close to Pegwell Bay. The turn of the river to the south seemed to have been caused by the bank of heavy shingle coming from the north which forced the river back to Sandwich. Then for some reason the flow of shingle ceased from the north, and the drift coming up from the south forced the river right back to its original outlet near Pegwell. The shingle which came from the north contained a large proportion of large stones which had apparently travelled only a short distance, and presumably had come from the Ramsgate cliffs. The whole instance was interesting as showing a definite change in the drift of shingle Another instance of a river being turned in its course by shingle was that of Shoreham, where the shingle coming from the west had gradually forced the River Adur far to the eastward and had blocked the town of Shoreham from the immediate access to the sea, which it enjoyed in Roman times. With regard to the Chairman's remarks on Dover Harbour, he happened to know the harbour well, and did not think that the remarks which the Chairman had made were quite just. Dover Harbour could be entered by the eastern entrance in any state of the weather

THE CHAIRMAN said he was only relating what a skipper told him, who said it was not possible to get into Dover Harbour in stormy weather.

MR. COLSON said that he thought it was possible to get into Dover Harbour by the eastern entrance in any weather, although owing to the position of the western entrance access by that entrance during a south-western gale was not so easy. As regards the silting being abnormal, he could only say in justice to Sir William Matthews, Past President, Inst.C E., who designed the harbour, that the silting which had actually occurred was just what Sir William had predicted in his report on the conditions before the harbour was constructed. No doubt, at the present time, there was an accumulation of silt in the harbour because it had not been dredged for some years With regard to the statement that the Prince of Wales's Pier had silted up—while no doubt a certain amount of silt had accumulated on the western side of the pier, on the eastern side there was deep water, and this deep water had, in fact,

been increased during the war owing to the alteration in the currents in the harbour which had been caused by the position in which certain ships had been sunk during the war to protect the harbour against torpedo attacks.

CAPTAIN I. J. GRAY said he had been engaged wholly on sea defence work for a number of years, and since then he had made it his business to keep himself acquainted with the progress made in that branch of engineering. In every sea defence problem one had to study a number of phenomena, marine, metallurgical and geological, and, besides that, collect old and new data. The data which one obtained were not altogether satisfactory, and if they were they would not be conclusive, like mathematical facts leading to a solution What they arrived at was a general result General inferences were a complex made up of applied science and experience, but experience played by far the larger part in ocean defence. Unless the sea defence engineer had had a long and varied experience—an experience such as the author had had he would find himself up against a problem the individuality of which would jeopardise the soundness of his conclusions. He submitted that it was not only desirable, but often necessary, and it was undoubtedly possible, to raise the level of sea defence work so that it partook more of the nature of an applied science than it had hitherto done. Scientists had discussed tides and waves in mathematical terms, and there remained a large number of phenomena which might be scientifically investigated. There was a wide field of research in which scientists and engineers might co-operate, but it was not the work of individual effort, and he suggested that a Committee representative of engineers interested in tidal matters, should draw up a syllabus of problems in which research was required. He would make no attempt to indicate them himself, but he had no doubt that amongst those present such a syllabus of problems could be mentioned quite easily. Engineering societies had not done what was wanted. Papers were read describing successes, but one never heard a paper on sea defence describing a failure, and failures were not infrequent. Every equinox told the tale, and if there was no society dealing with sea defence on scientific lines, he saw no alternative except waiting until there was a Government which would act generously on the lines of the Commission on Sea Defence which was appointed some years ago. In the existing circumstances of national finance, he was afraid that it could not be discussed.

THE CHAIRMAN proposed a vote of thanks to Professor Matthews for his paper. He himself had been engaged and employed in many shore service matters, and the removal of shingle was the one great trouble. He could specially call to mind one case which occurred in the locality of Dublin. A certain portion of the coast had a railway line, the South Eastern line, which ran close to the shore over the top of the 20 feet sea wall. There was a lot of very heavy shingle there, and very little sand on the shore at all. A certain man made a practice of taking hundreds of tons of that, and got a large sum by selling it. He interviewed the railway company, and found that the man had a perfect right to take the whole of the shingle because it belonged to him, but on the other hand, he was jeopardising the existence of the railway line, and so the case came into Court He was giving expert evidence to the railway company, and was cross-examined by one of the leading lights of the Irish Bar, Mr. Stephen Ronan, K C, who said: "Are you quite sure that the sea wall protection is formed by the shingle that my client is taking, and was it there before my client was taking it?" He answered that it was a conditional question. Mr. Ronan said he wanted an answer, "Yes" or "No" He appealed to the Judge to allow him to ask Mr Ronan a question in order to put his point; the Judge gave permission, and he then asked Mr. Ronan: "Have you given up assaulting the police?" Of course he did not know what to say, because if he had said "Yes" it would mean that he had been in the habit of assaulting the police, and if he said "No," it meant that he was still in the habit of assaulting the police.

The motion was seconded and carried unanimously.

PROFESSOR MATTHEWS, in response, said it was extremely gratifying to him that the paper had been so well received. Coast erosion was probably the greatest difficulty that any engineer had to contend with, and there was no branch of the engineering profession that was so discouraging as that of the maritime engineer, who specialised in coast protection. At Bexhill there were broken pieces of a sea defence on the shore, and the remains of a still previous wall. Instances like that could be found all round our coasts, and there was nothing more discouraging, and that was chiefly due to the fact that correct data could not always be obtained to guide an engineer in designing coast protection works. The conditions on the East Coast, e.g., were totally different from those on the West and South Coasts. He quite agreed with what had been said with regard to the drift at Holderness, and in his opinion the accumulations that were taking place in the Humber and the Wash, had come directly from the Holderness Coast of Yorkshire. They could all learn a good deal from failures, and when he was called in to advise a local authority, he always made the fullest enquiries

from sea-faring men who knew the coast and the tide. Much valuable information could be obtained in this way. Lord Headley had referred to deep-sea erosion, and it would be interesting to the audience to know that the Chairman was one of the first who drew attention to this. Some years ago Lord Headley (when Mr Allanson-Winn) designed a chain cable groyne, which was carried out some distance below L W O S.T, and to which were attached faggots. This groyne was quite satisfactory, but the difficulty was in getting the attachments to adhere to the cable During storms, they soon washed away, but with reasonable attention, they did useful work in preventing drift of material along the shore below L.W M.

The proceedings then terminated.

Dr John S. Owens writes:—

I propose to refer to one point only in Professor Matthews' paper, that is, the wearing, or attrition, of concrete surfaces exposed to sea action. All engineers who have had occasion to observe works of concrete upon the foreshore where they are exposed to the action of coarse shingle have observed the rapid wear which often occurs. In the case of walls or groynes constructed by me upon the South Coast, where very coarse flint shingle is abundant, I have tried several methods to minimise this attrition. Wall faces were initially made from pre-cast blocks formed from elvan granite, as being the toughest obtainable stone. The face thus obtained was fairly resistant to attrition, but in course of time it wore away.

Since then walls have been faced with large flints, over about 4 inches diameter, set in concrete, and these have also stood fairly well, but I do not think they have withstood attrition appreciably better than the concrete blocks. I find that the peculiar property which the flints possess of fracturing easily under a sharp blow was most objectionable, and the surface of all flints exposed broke down by intersecting conical fractures, and gradually wore away.

On considering the causes leading to wear of concrete it appeared clear that if the pressure due to the impact of the stones against the face could be reduced it would help matters. A stone travelling at a high velocity under the influence of wave action, if suddenly checked by meeting a hard surface, will exert a pressure inversely proportional to the elastic depression of the surface, that is if the stone is brought up by striking a surface which depresses, say 1/100″, the pressure of the blow will be ten times as great as if the surface depressed 1/10″.

I, therefore, tried to obtain a resilient surface by coating the concrete with compositions of tar, pitch, etc., but these did not prove durable, and ultimately an experiment was made with wood block facing similar to a road pavement, the blocks being set with end grain on the surface. With due precautions to avoid expansion after setting, this wood block facing has stood the test of attrition better than any other surface.

One patch of such facing has been in existence for something over a year without any ill-effects, and a second patch which has been in for about four months shows very instructive results. A recent inspection of the second patch, which was exposed to great attrition by flint boulders, showed that the face of the blocks had suffered no observable wear, while the flint faced concrete surrounding the blocks, in which they were set, had been worn back below the face of the blocks by about ⅝″.

It is perhaps too soon to say that this is a solution of the problem of attrition, but I feel very hopeful. It is not to be expected that any material ill stand indefinitely when exposed to the grinding action of stones driven by the waves, but a material such as the wood block facing which resists attrition by virtue of the softening of the blow and of its own tough nature is very promising, especially as such a facing can be easily repaired if injured.

Mr. C. S. Meik writes:—

With reference to Mr. Colson's remark on the shingle outside Sandwich harbour, I am of opinion that the accumulation is due to the south-west sea running up channel; any sand in the bay being brought in by the sea under the action of north-easterly winds. Some few years ago I happened to be at Deal, and noticed the shingle had been scoured away, and the foreshore depressed to the extent of several feet during a northeasterly gale: two days afterwards, when the wind had gone round to the south-west, the whole of the shingle was replaced on the beach. This happened between Sandown Castle and the entrance to Sandwich Haven.

Prof. Henry Adams, M.Inst.C.E., writes:—

This very interesting paper presents a summary of all that is known upon the subject. The author shows very clearly that there is no standard design possible for protecting our coasts but that every case must be decided according to its circumstances. The Chesil bank and the action of the sea round Portland are a source of never-failing wonder and mystery. A very similar bank at Westward Ho is not referred to, but the same action has taken place there; a long ridge of cobblers' lap stones rises at the head of a wide sandy beach, with no indication of where they came from.

As to the travel of stones varying with the size, it should be noted that the bulk and, therefore, the resistance, varies with the cube of the mean dimension, while the area receiving impulse from the waves varies only with the square of the mean dimension; one would, therefore presume that the smaller stones would travel furthest. On the other hand the slope of a beach varies with the size of the particles,

shingle being steeper than sand in the proportion of its size. Where the beach is mixed the shingle generally takes the higher position and the sand the lower position. This would seen to be direct evidence that the larger material travels furthest.

The cooling of the earth during geological ages must of necessity have caused a shrinking and consequently a crumpling of the crust which is the cause of the mountain ranges and sea valleys. There have been continuous changes in the level of the land from this cause, and it is well known that similar changes are still in progress. One can hardly understand Mr. Clement Reid's opinion that "The rise of the sea level (*i.e.*, the subsidence of the land) may have been completed about 3,500 years ago, and only then commenced the coast erosion which we now see." There is no doubt that coast erosion is and has been continually in progress, more or less throughout the world, and that the tendency is to raise the bed of the oceans and seas and therefore to that extent raise the mean tide level. Where the erosion is greatest the travel along the coast will tend to increase the deposit at points where obstructions occur, but this will not alter the fact that much material is carried into the sea itself. The gradual rise of the mean tide level at Liverpool may, however, be due to the sinking of the land, but this could be determined by taking levels through from some distant point and checking by the Ordnance Survey. Buried forests at various points round the coast are direct evidence of the sinking of the land, but, as already shown, the land is constantly altering its level owing to the shrinkage of the earth's crust.

Reinforced concrete is a most valuable material for all sea-coast works. The ability to make a tied structure of any extent, with a face that gives little friction and can be shaped as desired, leads one to doubt whether anything better can be conceived. A few cases have been found, where from previous concrete or other cause some corrosion of the steel reinforcement has been caused by the sea water, but the use of rustless chrome steel would entirely prevent this possibility.

The writer's idea of coast protection is to prevent the travel of beach material along the coast by suitable reinforced concrete groynes, to protect the base of the cliffs by reinforced concrete walls, and to provide for the proper drainage of the adjacent land. The starving of the coast on the leeward side of the groynes, which is often objected to, is simply explained by the groynes not being continued sufficiently far along the coast. and that concerted action is necessary to prevent any one place benefiting at the expense of its neighbour. So long as the Government contend that coast protection is a local and not a national matter, so long shall we have periodical outbursts of indignation at the ineffective action taken to preserve our coasts.

Mr. A. E. Carey, M.Inst.C.E., writes :—

Professor Matthews' paper affords a useful summary of recorded data bearing on the subject of Coast Erosion. He does not directly indicate the State measures which he considers essential to the solution of the problem.

In Appendix No. XVII. of the report of the Royal Commission, I elaborated a "Memorandum with regard to the Proposed Creation of Coast Commissioners," and in Chapter 13 of "Tidal Lands," the authors have dealt with this subject somewhat fully, sketching in outline a draft of the Act of Parliament which, in their judgment, would meet the case It is safe to say that if, to-morrow, a benevolent despot could be appointed, whose function it should be to control the problem of erosion, that problem would speedily cease to be acute. The inherent difficulties of the situation arise from the vast complexity of authorities and their lack of united action, coupled with the difficulty of finance.

It is quite certain that the benevolent despot, when installed in office, would call to his aid the services of the horticulturist. The lack of interest shewn in the comparatively simple operation of transforming our foreshores by the agency of vegetation is somewhat amazing in a country in which horticulture in all its branches is a passion with almost every class. The authors of "Tidal Lands" ventured to suggest that sea-side gardening might some day become a recognised branch of horticulture, but, so far as I am aware, with the exception of the protection of the cliffs at Bournemouth by the growth of succulents, which had been so successfully inaugurated by Mr. Dolamore, the Borough Engineer, there is little trace of any attempt at this novel art. Mr. Dolamore has planted the Giant Mesembryanthemum (*Cereus rosea*) on the cliffs, having found it indigenous in Cornwall and Devon. He has clothed some of the slopes with both the yellow and blue varieties.

The horticulturist who has to deal with the difficulties of shingle protection would undoubtedly call to his aid the plantation of *Sueda fruticosa*, one of the most useful of allies.

Mr. Chilvers, of Hunstanton, has been growing Sueda freely for the purposes of coast protection, but, so far as I know, his efforts in that direction have not met with the success they deserve.

In recent years my firm have had, in a number of instances, to advise on coast erosion, and have also been responsible for the wardenship of considerable tracts of sea walling. In every case the endeavour has been made to carry out the necessary measures with the minimum of expenditure. There are large areas of the sea shore in process of erosion or falling into dis-

service by reason of the encroachment of the sea, which, in my opinion, could be maintained in being at relatively small expenditure. The view prevalent a few years back was that, considering the stupendous forces at work upon sea shores, vast and elaborate measures of defence were necessary. The modern school has, perhaps, gone to the other extreme. It regards non-heroic methods of shore and cliff plantation and arrest as the key to the solution of the problem.

MR. SAMUEL DYER, M.I.MUNL.E. (Bridlington) writes:—During the years when Mr. Matthews was our Borough Engineer and Surveyor, he had unique opportunities of watching the action of the sea, and devoted much time and thought to the subject, and shewed great ability in designing and carrying out works of prevention. Unfortunately, this is a district in which the sea has made terrible inroads upon the land; whole villages have been swept away and a bay formed from Flamborough Head to Kilnsea, a bee line of 35 or 36 miles, and having a depth of 7 miles.

MR R. F GRANTHAM, M.Inst.C.E., writes:—

I should like to point out that while erosion of cliffs by the sea causes loss of land over a much greater length than any other kind of encroachment, the sea advances on the land in a different way where low land is protected only by the high ridges of shingle banks and by sand dunes, and protection of those low-lying lands is more difficult than that of land on cliffs.

In the case of high shingle banks, the sea in violent storms throws the high ridge back and deposits the shingle at the back in long talus fans of flat slopes, thus gradually encroaching on the low land. This was happening at Lancing and Shoreham until groyning work stopped it. It is happening now on the marshes in rear of the long ridge of shingle bank mentioned by the author on the Norfolk Coast, extending from Weybourne, which I have recently had occasion to inspect.

In some parts where the coast is protected by the sand dunes, the encroachment of the sea is almost imperceptible, but it is, nevertheless, in progress. The tides fret away a small portion of the foot of the dunes and the front slopes then fall down and the sea advances while the sand dunes recede. I have seen this in progress on the east coast of Norfolk.

I did not think that any engineer would dispute, as the author appears to question, the accuracy of the conclusions arrived at by the late Sir John Coode from his extended and most careful observations of the movement of the shingle on the Chesil beach as described before the Institution of Civil Engineers in 1853. I have seen over and over again after violent storms on the south coast the largest stones on the shore, mostly chalk flints, thrown up to the top of the beach on the west sides of the groynes, while the smaller stones are left lower down. This fact, as it seems to me, fully confirms Sir John Coode's conclusions on the subject. I do not see how indentations on the Dorset coast, as the author suggests, can affect the movement of the shingle on the straight run of 10 miles of the Chesil beach.

The author is under a misapprehension when he states with reference to Shoreham Harbour "since the pier was extended it has been impossible for any of the material to travel eastwards." The west pier was extended about 150 feet in about the year 1879 by Mr. (afterwards Sir) Alexander Meadow Rendel. I have recently prepared plans for the repair of part of the extension. I have also been engaged for many years on works on the coast between Worthing and Shoreham Harbour on the west side of the pier and have had occasion within the last two years to inspect for some months and report upon the conditions of the beach and groynes on the east side of the pier. I am, therfeore, fairly well acquainted with the movement of the drift of the coast.

So far from it being impossible for material to drift eastwards of the pier, I can assure the author that very large quantities enter the harbour and also pass the pier and are deposited all along the beach on the east side of it. The Harbour Trustees have since the pier was extended been compelled to dredge from 60,000 to 120,000 tons of shingle annually from the harbour to keep it clear. I have also seen large banks of shingle deposited by the tide on the east side of the pier, the shingle from them being gradually washed up on the beach eastwards. The pier does not stop the movement of shingle eastwards at all. If it did the large quantities of shingle now to be seen on the beaches at Hove and Brighton could not be maintained.

Harbour piers, as a rule, do not ultimately intercept the passage of all drift material. The conditions at Madras Harbour, which the author quotes, are a striking example of the difficulty of stopping the drift material and of keeping harbours clear of it.

The author refers to Dungeness, quoting from the late Mr. W. H. Wheeler's book "Sea Coast."

I have never been able to accept Mr. Wheeler's statement that the only source of supply of shingle forming the immense bank of the area of Dungeness is derived from cliffs between Dungeness and Beachy Head. So far as I have been able to investigate the question, those cliffs could not have yielded the enormous quantities deposited there. A great deal of the shingle must have travelled a long way from the west. The Rev. F. Gell, formerly Vicar of Lydd, sent in 1895 to the British Association Committee on the Erosion of the Sea Coasts a list of various pebbles found at Dungeness. Among them were quartzite, similar to pebbles

from Budleigh Salterton, Porphyritic felsite-quartz porphyry, possibly Cornish elvans, granite and hornblende porphyry. These are not products from the Hastings and Beachy Head cliffs. I have myself picked up Budleigh-Salterton pebbles on the shore west of Little-hampton and on the shore east of Chichester Harbour.

"Deep sea erosion" is a term which has frequently been used in connection with erosion of the coast I should be glad if the author could explain what in this connection "deep sea" means—that is to say, in figures of depth. I have seen quantities of chalk flint with seaweed attachments thrown upon the shore after violent storms, but they could not have come from a greater depth than a fathom or two In-vestigations have been made of the conditions of life at great depths in the ocean where the deep sea is reckoned by hundreds of fathoms. It seems likely to lead to misconception to apply the term "deep sea" to comparatively shallow depths of water. The cavities left by the stones with seaweed attachments are soon filled with sand or shingle. According to the late Mr. John Murray, who read a paper on "The North Sea" before the Insitution of Civil Engineers in 1861, that sea is gradually shoaling, and it is nowhere deeper than 100 fathoms, except on the margin of the Norwegian coast.

I agree with the author that groynes are necessary for the protection of most sea walls. But I have found it quite practicable in several cases to stop the erosion of cliffs by means of groynes without any sea wall or breast-work of any kind, although the process is rather slow.

The author refers to the large reclamation scheme for enclosing 150,000 acres in the Wash in about the year 1840 This area was sub-sequently reduced to 75,000 acres and again to 32,000 acres. If such a scheme had been carried out it would have enclosed an area utterly unfit for reclamation and absolutely useless for any purpose whatsoever. An embankment was started and small remains of it are still to be seen. The result of the Estuary Company's operations has been to reclaim about 2,400 acres in a period of over 60 years. The Company, however, has judiciously enclosed by degrees only land which was really fit for agricultural purposes.

One other point which I think requires qualification. According to my experience marsh land is much more valuable than cliff land.

An owner of marsh land fronting the North Sea informed me within the last three weeks that he let his marshes for £2 10s. to £3 per acre. Marshes in Essex and in Lincolnshire have frequently been let by auction for at least £4 per acre for pasture. Where is the agricultural land on wasting cliffs that produces equal values or anything like them ?

MR. A. T. WALMISLEY, M.Inst. C.E., Dover Harbour, writes:—

I agree with the statement that "the larger materials," are forced against the base of a cliff, leaving the sand to settle near low water, as the larger material, unless too heavy to be pushed forward by the travel resulting from the action of waves, presents a surface for the force of water to act upon, which the small particles of sand cannot claim There is in such cir-cumstances a wave of oscillation acted upon by the prevailing wind. which becomes a wave of translation when a solid obstruction to its revolution is encountered, and this translation upon a beach foreshore is resisted by properly constructed groynes, carried well into low water, so that the foreshore elements are not conveyed round the toe of the groyne, and the construction should also be carried up to a sea wall or slope above the level of high water. I have no sympathy with short groynes, the length of which does not include the position of high and low water levels, and I cannot favour cutting a hole in a groyne to allow shingle to travel through a groyne, when the beach upon the lee side is much below the beach upon the windward side of the groyne This has been done at some seaside places, about the level of high water, neap tide, but so far as I know, this plan has never given satisfaction, as it produces scour The groynes are best constructed when the verticals of a timber construction allow the top level of the groyne to be raised or lowered, to suit accumulations of beach Old railway rails, pointed and driven vertically, form excellent supports for this purpose, but need cautionary methods when small boats have to pass over the site between high and low water levels

Under "Causes of Coast Erosion," the author alludes to Lowestoft, where an unstable wall upon the south beach facing the sea was built by contractors to retain the ground behind the wall, and they were told that in doing so, they must not take the beach for concrete. Consequently when the surface of the beach in front of the wall covering its toe receded, the wall was subject to undermining, owing to the insufficient groyning at that time (1892), but the contractors argued that as it was specified that the beach was not to be interfered with, they were justified in concluding that the groyne would receive sufficient attention to retain the beach. and the wall was not designed to stand without the aid of the beach to protect its footings The range of tide here is 6′ 6″. Of course, under the circumstances, the base of the wall should have received the aid of piles, cylinders or caissons, to obtain a sure foundation. Where there is ample width of foreshore to construct a marine drive or parade in front of the face of a cliff, at the back of a sea wall, this plan forms a protection to the cliff, as the water which breaks upon the wall. and falls

upon the parade, can be drained off the surface of the walk, as at Westgate-on-Sea, Folkestone and other places, without attacking the cliffs.

As regards a sea wall bounding the upper portion of a foreshore, Mr. Walmisley prefers a vertical wall. A curved faced wall does not tend to contribute more beach than a vertical wall. and the toe of a curved face wall being part of an inverted arch, is not so stable as the base of a vertical wall A curved faced wall may also need the introduction of a projecting cornice (as pointed out by the author), to divert the water from leaping the wall and falling to some extent upon the retained road or promenade at the back, and if inserted below the coping, will tend to raise it out of level, whereas projecting offsets to the face of the wall where their bed is embedded in the structure, so that the water cannot press underneath this projection are beneficial, as in stormy weather they would protect the main foundation from the detrimental action of falling water. Such projections were formed of 9 ins in 6 to 1 concrete blocks, 6′ 6″ by 3′ 0″ depth in the retaining wall, faced with flints, at the west end of the parade at Sandgate, near Hythe, and were carried down to a clay level, but probably not sufficiently encased therein, so that the wall failed owing to the pressure of the high ground at the back of the wall, when aided by the recession of beach on the foreshore. Settlement resulted in most of the houses upon the land side of the carriage road, and a gas service underneath the inside footpath had to be ignited, to exhaust its supply from broken pipes beneath the asphalte surface.

The whole subject of Coast defence is of national importance, but it will be readily conceded that whatever is done in such matters, needs watching with a view to maintenance, whereby the demand for heavy future expenditure may be avoided.

MR. F. J WARING, C.M G., M.Inst C E., writes : —

I agree generally as to the causes leading to erosion, as given in the paper, but think it difficult sometimes to account for this taking place at one spot, while at another, close by, accretion is apparently in progress. Thus, in Eastbourne, groynes are in existence along the sea front to check the travel of the shingle which, if unchecked, would probably result in erosion, while to the east of that town there are no groynes, but accretion is taking place, and that accretion must have been in progress for centuries, as, at a point distant about 1½ miles from the Coastguard Station at the east of the town, the shingle extends inland to the Pevensey Road, which there is approximately a mile from the present shore line.

As regards the best means to be taken to prevent or check erosion, it is almost impossible to lay down any general rule as this should be determined by the local conditions applicable to each particular case. I might mention that on the west coast of Ceylon, where the range of tide is only some two feet, and the seas are not nearly so heavy as those met with at many parts of the coasts of the British Isles, the sandy foreshore is being eroded, thus endangering the railway which at the place runs at the extreme edge of the shore The Colonial authorities proposed, as a remedy, the erection of a sea wall founded on concrete cylinders. Upon the matter being referred to my late firm, the opinion was given that the erection of this wall was unadvisable, as the recoil of the waves from its face would intensify the erosion and ultimately entail the need for protecting the wall itself by a rubble facing or otherwise. There being abundance of gneiss rock available within a reasonable distance, the formation of a rough rubble facing laid to a fairly flat slope was recommended, the stones in the face exposed to the sea to weigh from 3 to 9 tons, any smaller material quarried being used in the hearting and backing The work was carried out in this manner for a distance of some 2¾ miles, at a cost of rather more than one-fifth of the estimated cost of the sea wall, and it was finished at the end of 1913 The result has been quite satisfactory, and though, as was foreseen, some little settlement into the sandy shore on which it was founded has occurred, the cost of its maintenance has been but small

MR ERNEST LATHAM, M Inst C.E., writes :—

If there is any criticism which can usefully be made, it would be a regret on my part that the "prevention" side of the paper is not further elaborated With nearly all the views expressed by Professor Matthews, I am in agreement. The following remarks, therefore, are principally confined to those points on which Professor Matthews and I are not in absolute accord :—

Professor Matthews states that "Rows of piles have sometimes been driven parallel with the shore, and a few feet seawards of the cliffs or sea wall, but these have been quite unsuccessful."

This is a generalisation which is not always correct. My firm (Messrs. Carey & Latham) recently advised the Somerset County Council in regard to the protection of the Minehead-Watchet road. A leading feature of the design was a double system of open piled stockades on the foreshore and running parallel with the lateral defences. Acting under this advice, the County Council have spent over £30,000. The prevalent wind on this coast is from the West and North-West, and the stockades are successfully collecting the beach material in front of the sea wall. The beach consists of shingle graded up from the fine particles to 6in. material. Some interesting photographs of this work appeared in the "British Builder,"

dated February, 1922. I agree in general with Professor Matthews' conclusions as to groynes and the provision of an adjustable crest near high water mark, although he belongs to that school of engineers who admittedly avoid the construction of groynes and only adopt them as a last resource.

During the construction of the works above referred to, and before completion, a bad wash-out occurred, and the last resource was adopted in modified form. This modified form involved a groyne of low elevation and a wide base, 18 feet in the case under review. The groynes were of mass concrete about 4 ft 6in. high and only extended some 20 ft. seawards of high water mark The section of groyne was given an easy gradient on both sides, and these groynes functioned as a sort of non-return weir over which the beach material was driven by the prevailing winds and the influence of the flood tide The beach loss under adverse winds being less than the gain under favourable winds, a steady accretion has occurred along the toe of the bullnosed sea wall now carrying the county road.

It is undoubtedly a source of regret that national economies have resulted in the disappearance of the Lands Reclamation Department of the Ministry of Agriculture and it certainly appears as though the problem of coast erosion will continue to remain, as hitherto, a local and not a national problem.

It will interest Professor Matthews to know that I reported to the War Office in 1914, in connection with the Orfordness Peninsula The rivers Alde and Ore are identical, and the menace of a severance of this Peninsula at the hamlet of Slaughden is as serious as ever.

In reply to the foregoing communications, PROFESSOR MATTHEWS writes:—

In reply to Mr. Ernest Latham, I stated that in my opinion rows of piles driven parallel with the shore were almost always unsuccessful, certainly 9 times out of 10; I am pleased to know that the work recently carried out by Messrs. Carey and Latham, in Somerset, has proved so successful. I have seen the article which appeared recently in the "British Builder," and noted with much interest this novel form of construction.

I was pleased to note that Prof. Adams' experience has shown him that, generally speaking, smaller stones on a shore travel furthest. I agree that reinforced concrete is one of the most valuable materials for all sea-coast works, and while occasionally examples of failure have been found, it is usually due to defective work. I do not agree with Prof. Adams that by extending the groynes on a shore erosion would be prevented. I am strongly of opinion that concerted action to prevent erosion is necessary.

I agree with Mr. Carey that it is difficult to formulate any entirely new points in connection with coast erosion and protection. It is also difficult to say what the State should do in the solving of this problem, but it is certainly disappointing to find that the "Lands Reclamation Department of the Ministry of Agriculture" has now been dispensed with.

The communication sent in by Mr. S. Dyer, of Bridlington, is interesting in that it points out that the greatest erosion occurring around our coasts is on the Holderness Coast of Yorkshire, where I resided for some years and made a careful study of the tides, and wave-action, and erosion.

Mr. Grantham's remarks are interesting and important. I agree that it is more difficult to protect low-lying land (say marsh land) than to prevent erosion of cliffs. I agree with Mr. Grantham that even where sand dunes protect a coast encroachment by the sea is often in progress, although it is imperceptible. In regard to Mr Grantham's reference to the most careful observations of the movement of the shingle on the Chesil beach, no one appreciates the splendid work in this direction, performed by the late Sir John Coode, more than myself, and I would not think of setting my opinion against that of Sir John; but I have observed on various parts of our coasts that the smaller material travels farthest; in the case of the Chesil bank (according to Sir John) the reverse is the case.

With regard to Shoreham Harbour, probably I was not quite accurate in saying that it was impossible for *any* of the material to travel eastwards. Mr Grantham would probably admit that very little material does travel eastward, and the quantity which accumulates in the harbour mouth cannot be said to travel eastwards. It would be interesting to know what becomes of the 60,000 to 120,000 tons of shingle annually removed from the harbour.

As to Dungeness I am inclined to agree with Mr. Grantham that the cliffs at Hastings have not in themselves supplied the whole of the material that we find at Dungeness, but that some of this has travelled from parts of the coast much further westward than Hastings.

Regarding "deep-sea erosion," by this I mean erosion considerably below low-water mark (spring tides) and anything up to say 7 fathoms deep. I am pleased to know that Mr. Grantham has found it possible in several cases to stop the erosion of cliffs by means of groynes only without any sea wall or breastwork of any kind. I have, unfortunately, not been so successful.

I am glad that Mr. Walmisley agrees that it is wise to carry groynes down to low water mark so that material will not escape around the toe of the groyne, and that he has no sympathy with short groynes.

As to the suggested opening through the upper portion of a groyne (at the shore end)

I would say that I have not introduced this method, but that I have seen it adopted at Clacton, and upon enquiry was informed that the method worked well. Mr. Walmisley's reference to certain unstable walls upon the south beach at Lowestoft, shows clearly that the best workmanship should be put in in the carrying out of coast protection works. I have seen these defective walls and agree that whatever works are carried out should be substantial having in mind the cost of maintenance.

The communication sent in by Dr. John S. Owens is particularly interesting as it deals, among other matters, with the wearing action of concrete blocks or mass concrete sea walls faced with flints, and it is useful to know that he has come to the conclusion that concrete blocks faced with flints, which form the face of a sea wall, withstand attrition (caused by the sharp flints on the shore being hurled at the wall in a heavy storm) no better than plain concrete blocks. His investigations are very interesting. I, however, do not agree with Dr. Owens' novel method of facing a sea wall with wood blocks; there must in my opinion be an expansion and contraction of the blocks according to the temperature and a splitting of the blocks as one finds often in wood block paving on the road.

I am indebted to Dr. Owens for the use of a number of interesting slides illustrating groynes and sea walls, designed and constructed by him.

In reply to the written remarks of Mr. F. J. Waring, I agree that there is a good deal of difference of opinion as to the causes of coast erosion, but I believe that the causes set out in the paper are the principal ones. I have often observed that alarming erosion and considerable accretion are in progress together on quite a short length of coast. The Eastbourne example referred to by Mr. Waring is particularly interesting. There is no general rule that can be laid down when designing a scheme for coast protection: local conditions affect the scheme considerably.

NOTES ON BOOKS.

THE MINERAL RESOURCES OF BURMA. By N. M. Penzer, M.A., F.R.G.S., F.G.S. London: George Routledge & Sons, Ltd.; New York E. P. Dutton & Co.

The Federation of British Industries, under whose auspices this book is published, has done well in calling attention to the mineral resources of Burma. The potential wealth of the country is very great, but at present its development is rendered almost impossible by the lack of adequate means of communication. If this could be remedied, there is little doubt that a swift and enormous development of the mineral resources of the country would follow, with the result that our industries would be enabled to obtain large quantities of raw materials from within the Empire, and, at the same time, a demand would be created for machinery and many other kinds of goods, the bulk of which would naturally be supplied by this country

Mr. Penzer's volume is to be commended as giving in a handy form a comprehensive account of the minerals of Burma. After an introductory chapter describing generally the climate, physical features and roads and railways of the country, the author proceeds to deal with the minerals *seriatim.* Gems and precious stones are first discussed. The average annual output of rubies, sapphires and spinels during the five years 1909-13 was 283,439 carats, valued at £63,272, and the industry employs some 1,300 to 1,500 men. Jade is a mineral of some commercial importance The jade mines in the Kachin Hills are only worked for three months in the year, and the methods are primitive, During the heavy rains, all work is stopped by malaria, and before mining is re-started, it is necessary to bale out the water which has collected, and to renew timber which has fallen in or rotted. The output for 1918-19 was 3,336 cwt., valued at £91,456. With more scientific methods of production, these figures could, no doubt, be multiplied many times

Some interesting particulars are given showing the increase in the production of tin. In 1898 this amounted to only 39 tons, valued at £2,553; by 1913 it had risen to 353 tons valued at £47,384 During the war years 1914-18, the average production of tin and tin ore in the Indian Empire, was 11,981.7 cwts., valued at £73,376.

The extraordinarily rapid growth in the petroleum industry is due mainly to the Burma Oil Company. Their first bore was sunk in 1887 in Khodaung. In 1900, the production from machine bores was 19,030,196 gallons. In 1919, the total number of gallons from the Burma oil fields reached the great figure 293,748,807

An interesting feature of the book is a map of Burma showing at a glance the districts in which the various minerals are found; and the volume concludes with a full bibliography which will be very valuable to those who desire to study the subject in greater detail.

PUNJAB CEMENT INDUSTRY.

To travellers, whether by road or rail between Pindi and Peshawar, the grey hill and shrine of Baba Wali Kandahari, rising abruptly from the plain above the village of Hasan Abdal, are well-known features of the landscape. Beneath its western slopes lie the sylvan groves sacred to the memory of Lala Rookh, fickle slave mistress of Jehangir. Her tragic end no less than the legend of her illicit love has carried her name down to posterity and, her tears, so the story goes, still flow perennially from beneath her living tomb. To the south-east rise the turrets of the ancient house of Wah,

a halting place of Mogul emperors on their excursions to and from Kashmir, the gateway of whose garden palace still stands among the ruins of a greater splendour A change has come over the scene in the last few years, which bids fair to bring the name of Wah out of its slumbers into the forefront of utilitarian fame.

It has been said that the measure of a country's prosperity may be gauged in these days of industrial progress by the extent of its cement interest Whether or not this is true, it is a fact that without cheap and plentiful supplies of Portland cement the progress of industrial development is greatly hindered and that the recent industrial awakening of India generally has synchronised with the development of the manufacture of Portland cement in various parts of the country, so far mainly in the centre of the Peninsula and on the west coast.

Now, as recently forecasted by H.E the Governor, the Punjab, not to be behind the rest of India in industrial advance, is to possess a cement factory of its own and the site selected is to the east of the hill of Baba Wali Kandahari, giving it a new and wider interest than it has hitherto held.

The site which was selected by the promoters, Messrs. Killick Nixon & Co., of Bombay, after an exhaustive examination of the possibilities of many other areas, possesses the essentials of an inexhaustible supply of limestone and clay of admirable quality for the manufacture of first-class Portland cement. It is conveniently situated close to the main line of railway to Peshawar, and a new station has recently been opened by the N.W. Railway, called Wah. Ample sidings have been provided to serve the company's works and the quarries of the Wah Stone Quarry and Lime Co., Ltd., which adjoin the cement company's site. An abundant supply of clear cold water is available from the Chablat river which is fed by innumerable and copious springs, whose source is the snowy ranges of the Himalayas.

The Machinery at Work.

On this site have sprung up in the last 12 months a number of buildings wherein machines will be installed and the various processes will be performed.

Taken in order, there will be first the Raw Mill, a 50ft. high building of brick, where blocks of limestone from the hill are to be broken by giant jawcrushers, situated below ground level, into pieces the size of a man's hand and less. By means of 50ft. elevators these will be fed together with clay pumped from the Clay Wash Mill, into the kominors and tubemills, revolving drums, in which the mixture is to be ground by means of hardened steel balls and flint pebbles, to a pasty slurry of the consistency of pea-soup. Passing from these mills, the "soup" will be "agitated" in circular vats 66ft. in circumference by means of compressed air and stirring arms to churn the liquid to an "intimate" mixture of the particles of lime and clay On the correctness of the proportions of these ingredients depends in a large measure the quality of the cement produced, and here any want of knowledge or carelessness on the part of the chemists, who are continually testing and adjusting the mixture day and night, would have disastrous effects

The next building is the Kiln House, some 200 feet in length and 50 in height. Here the slurry from the correction vats will be raised by pumps to the Kiln feed to disappear into the revolving steel cylinder, 170ft. long and 7ft. to 8ft. in diameter, known as the rotary kiln This is in appearance a giant telescope on massive concrete foundations sloping gently from the "eyepiece" or "feed" end to the "objective" or "firing" end Down this cylinder, as it revolves, first flows the slurry which, as the moisture is driven off on meeting the heat of the 15ft flame of coal dust and air which is blown through the kiln from the firing platform, gradually becomes "clinker."

From the kiln the burnt clinker will drop to the "clinker cooler"—another rotating cylinder where it will meet a refreshing blast of cool air from a fan, and thence to a shaking conveyor which jerks the now cooled clinker to a hopper, whence it will be elevated to the cement mills. Here it is finally pulverised to the fineness required for "Portland Cement," as known to the general public

It now remains for it to be stored in silos and thence automatically weighed into those familiar bags in which it reaches the consumer.

The whole of the plant will be driven electrically by a steam-driven turbo-generator of 1,500 K.W.—probably the most modern unit of its type in the Pubjab.

The staff employed has had a wide experience, not only of cement manufacture, but of its manufacture under Indian conditions at the Bundi Portland Cement Co.'s works in Rajputana, which are under the control of the same agents and where the best cement so far made in India is produced.

STAMPING PRACTICE IN BRITAIN AND AMERICA.

In instituting a comparison between the stamps and stamping processes current in the United States and those of this country, several interesting features claim attention

In this country, the gravity drop type is the only kind of stamp. The mechanisms for lifting the tup fall into three categories: (a) the kick stamp with a simple belt taken over a friction pulley; (b) the steam lifter with rotary piston; and (c) the friction lift with power clutch. It should be noted, however, that types (b) and (c) are rapidly superseding type (a) in all but the smallest sizes.

There are but two types of stamp in general use in the United States—the friction stamp known as the board drop, and a specially designed steam hammer. Both of these are arranged to be worked by the stamper himself, and even where assistants are necessary to handle the job, the control, generally by foot lever, is under the stamper.

In the board drop and other gravity stamps the velocity of striking depends solely on the height of the drop; but in the steam stamp the steam is used to raise the tup and also to force it down. Hence for a given striking velocity a shorter stroke can be used, and the time taken by both up and down strokes proportionately reduced. Blows can therefore be obtained more rapidly from the steam stamp, which is a definite advantage as regards output. The American board drop is usually 5 to 6 ft., as compared with the drop of 7 ft. which is the rule with gravity stamps in this country.

American stamps differ in construction very considerably from common British practice. In America the stamps are built entirely on their anvil blocks, while British drop stamps follow steam-hammer practice. Foundation elasticity is obtained in the United States by the expensive expedient of bedding on timber to a depth of several feet: but their method of fitting the tup guides to substantial headgear-carrying supports has many points of advantage.

Turning to the actual stamping processes, an outstanding feature of American practice is the preliminary forming, as well as the stamping of the article, as far as possible under the same stamp. A variant on the older method of using a dummying stamp alongside the main stamp is to use a fast-running steam-hammer for preparing a method by which a much bigger output per stamp is often obtained.

Summing up, the chief advantages of American processes would appear to be (*a*) rapidity of stroke due to reduction of drop; (*b*) rigid holding of the bottom die and correct guiding: (*c*) reduction of interruptions due to more effective preparation

GENERAL NOTES.

Victoria and Albert Museum: International Theatre Exhibition.—The International Theatre Exhibition at the Victoria and Albert Museum, will be open free daily to the public from June 3rd to July 16th. The large expenses of the Exhibition are being met entirely by private subscription, and subscribers of £1 and upwards will receive two tickets covering admission to a course of six lectures which will be given in the six weeks during which the Exhibition is open. Subscriptions should be sent to Lord Howard de Walden, The British Drama League, 10, King Street, W.C. 2. The Lectures will be at 5 p.m., as follows:—Tuesday, June 6th—Mr. Gordon Craig, "The International Theatre." Chairman: Sir Cecil Smith. Tuesday, June 13th—Mr. H. Granville-Barker, "Co-operation in the Theatre." Chairman: Lord Crawford. Thursday, June 22nd—Mr. George Bernard Shaw, "The Evolution of the Theatre" Chairman: Miss Lena Ashwell. Tuesday, June 27th—Sir John Martin Harvey, "The Actor in the Theatre." Chairman: Viscount Burnham. Tuesday, July 4th—Mr. John Drinkwater, "The Dramatist in the Theatre." Tuesday, July 11th—Mr. Basil Dean, "What goes on behind the Scenes." Chairman: Mr Norman Wilkinson.

Exports of Babassu Nuts from Brazil.—Exports of babassu and piassava nuts from Brazilian ports during the years 1915 to 1920, according to figures recently published by the Ministry of Agriculture, Industry and Commerce, were as follows (given in kilos of 2.2046 pounds):

Ports.	1915	1916	1917
	Kilos	*Kilos.*	*Kilos*
Manaos	130	....	....
Para	....	....	240
Maranhao	1,265,528	1,089,832	656,855
Cajueiro.........	2,991,599	1,428,724	1,286,694
Fortaleza	501	....	....
Bahia	64,749	41,960	3,000
Rio de Janeiro	1,300	....	2,370
Santos	....	....	678,915
Total	4,323,817	2,560,516	2,628,074

Ports.	1918	1919	1920
	Kilos	*Kilos.*	*Kilos.*
Manaos	....	....	....
Para	401,900	....	....
Maranhao ...	849,830	5,644,705	2,334,886
Cajueiro	2,649,688	4,774,045	4,243,050
Fortaleza	552,295	8,972	3,890
Bahia	205,633	31,838	90,070
Rio de Janeiro	....	296,542	118
Santos	1,650,060	279,740	....
	6,309,406	11,035,842	6,672,014

In forwarding the foregoing figures, the United States Consul at Pernambuco remarks that, with the exception of the figures for Bahia, all the quantities given are of babassu nuts.

Proposed Railway to Mecca.—A group of wealthy Arab residents of Mecca is reported to have been organised recently in order to undertake an extension of the railway from Medina to Mecca—a distance of about 375 miles. This extension, writes the United States Consul at Aden, would give Mecca rail connection with Damascus and Aleppo, and thence with Scutari on the Bosphorus, opposite Constantinople.

Experimental Cottages.—In 1918 the Department of Scientific and Industrial Research was approached by the Ministry of Agriculture and Fisheries with a view to co-operation in erecting a few experimental cottages to test various methods of building with local materials, and such new construction of floors, roofing, etc., as might be thought promising. Of the 33 cottages erected by the Ministry by direct labour, and forming the Farm Colony at Amesbury, 5 were constructed to the designs of the Department of Scientific and Industrial Research. Without expressing any opinion on the success or failure of the experimental features the Department considers that a description of the work may be of general interest, and the report prepared by Mr. W. R. Jaggard, who was Architectural Consultant, is now published. The external walls of the several cottages were of brick, concrete, chalk and cement, rammed chalk and straw, and chalk pisé, respectively. Various experimental designs of floors, roofs, stairs, fittings and heating appliances have been used The report gives descriptions of all the cottages and of the experimental features embodied, and where possible, relative costs of the different methods employed. It is illustrated by 93 photographs and drawings, and may be obtained from H M Stationery Office.

Platinum in Brazil.—It was recently reported that platinum has been discovered in the State of Parahyba do Norte, Brazil According to the United States Consul at Pernambuco, the deposit is on a mountain ridge three miles from the main motor road leading from Campina Grande to Patos. Regular transport services now operate over this road, and it is understood that a branch from the main road to the deposit could be easily constructed For the present the owner proposes to establish an extracting plant at the deposit and bring the ore out by truck.

Fibroferrite.—A newly discovered metalliferous substance possessing unusually strong solvent properties is being prepared for commercial use at Central Greta, New South Wales (about 125 miles from Sydney), writes the United States Consul at Sydney, and gives promise of the development of extensive new industries. This mineral, known as fibro-ferrite, is composed so it is stated, of ferrous sulphate, 50 per cent.; oil of vitriol, 15 per cent.; ferric sulphite, 10 per cent.; and several alums and sulphur compounds. It is a very potent combination when used as a solvent for various organic substances, and the constituents of the mineral are already being employed in the manufacture of red oxide of iron, disinfectants, dyestuffs, and copperas. Four patents have been obtained for the use of the mineral, great quantities of which are deposited in the Greta district.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Tuesday, June 6..Royal Institution, Albemarle Street, W., 3 p.m. Sir Percy Sykes, "The Foundation of the Persian Empire."
Alpine Club, 23, Savile Row, W., 8.30 p.m. Rev. Canon G. M. Bell, "An Adventure in the Dent Blanche."
Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. Maurice Thiéry, "Le Théâtre de Maurice Donnay."

Wednesday, June 7..University of London, at the Imperial College of Science and Technology, South Kensington, S.W., 5.15 p.m. Dr. A. F. Holleman, "Recent Investigations on the Substitution in the Benzene Nucleus." At University College, Gower Street, W.C., 5.30 p.m. Prof. T. Borennis, "Past History of Art Teaching." (Lecture III.)
Archaeological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Mr. E. W. Lovegrove "Eleventh Century Work at Chester Cathedral."
Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m.
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. (Wireless Section), 6 p.m. 1. Mr. N. Lea, "The Performance of a Radio-Telegraphic Transmitter, with special reference to the New Installation at North Foreland." 2. Prof. C F. Jenkin, "A Dynamic Model of Tuned Electrical Circuits."
Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W 8 p.m. 1. Dr. J C Thresh, "The Action of Natural Waters on Lead." 2. Dr. H. E Annett and Mr. M N. Bose, "The Estimation of Meconic Acid in Opium." 3. Dr. A F. Joseph and Mr. F. J. Martin, "The Composition of Cows' Milk in the Sudan." 4. Mr. W Singleton, "The Use of the Daylight Lamp in Volumetric and Colorimetric Analysis."
Literature, Royal Society of, 2, Bloomsbury Square, W C 1., 5 p.m. Mr. H. Granville-Barker, "Some Tasks for Dramatic Scholarship."

Thursday, June 8..University of London, at King's College for Women, Campden Hill Road, W, 4 30 p.m. Prof. V. H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture VII.)
British Architects, Royal Institute of, 9, Conduit Street, W., 5 p m. Mr. D S. Maccoll, "What is Architectural Design?"
Historical Society, 22, Russell Square, W.C, 5 p.m. The Alexander Prize Essay.
Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. Joint Conference between Opthalmologists and Opticians on Spectacle Construction.
Royal Institution, Albemarle Street, W., 3 p.m. Rev. Dean Inge, "Theocracy." (Lecture III.)
Chemical Society, at the Institution of Mechanical Engineers, Storey's Gate, S.W, 8 p.m. Dr. H. H. Dale, "Chemical and Physiological Properties."

Friday, June 9..Royal Institution, Albemarle Street, W., 9 p.m. Prof. J. Barcroft, "Physiological Effects at High Altitudes in Peru."
Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.
Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W., 8 p.m.
Geologists Association, University College, Gower Street, W.C., 7.30 p.m. 1. Dr. A. E. Trueman, "The Liassic Rocks of Glamorgan." 2. Mr. C. C. Fagg, "The Recession of the Chalk Escarpment and the Development of Valleys in the Chalk between the Mole and the Darenth."
Physical Society, Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.

Saturday, June 10..Royal Institution, Albemarle Street, W., 3 p.m. Sir Hugh Allen, "Early Keyboard Music." (Lecture III.)
Municipal and County Engineers, Eastern District Meeting, at Harwich.

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FRIDAY, JUNE 9, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

TWENTY-FOURTH ORDINARY MEETING.

WEDNESDAY, MAY 31st, 1922; SIR CHARLES J. HOLMES, D.Litt., F.S.A., Director of the National Gallery, in the chair.

The following candidates were proposed for election as Fellows of the Society:—
Chaudhuri, S.N., M.A., Calcutta, India.
Stannard, H. Sylvester, Bedford.

The following candidates were balloted for and duly elected Fellows of the Society:—
Hansard, John Henry, Bookham, Surrey.
Munshi, Trambakrai M., London.
Ryland, John William, J.P., F.S.A., Rowington, Warwick.

A paper on "The Problem of Provincial Galleries and Art Museums, with special reference to Manchester" was read by MR. LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(Joint Meeting).

FRIDAY, MAY 5TH, 1922.

THE RT. HON. VISCOUNT BURNHAM, C.H., President of the Empire Press Union, in the chair.

THE CHAIRMAN said that as President of the Empire Press Union it was a peculiar pleasure to him to preside on the present occasion, because the newspaper press of the entire world took the greatest interest in the developments of wireless telegraphy and were all well aware of the immense services that had been rendered by Dr. Eccles to make it serviceable, not only for their purposes, but for mankind in general.

The paper read was:—

IMPERIAL WIRELESS COMMUNICATION.

BY PROFESSOR W. H. ECCLES, D.Sc., F.R.S.,
Vice-Chairman of the Wireless Telegraphy Commission.

In addressing the Dominions and Colonies and Indian Sections of the Royal Society of Arts on the subject of Imperial Wireless Communication, I know that I am speaking to those who have more to do with policy than I have, and I shall, therefore, limit myself to a plain statement of the facts which ought to be in the possession of those who wish to form their own opinion upon the proposal to erect an Imperial Chain of Wireless Stations. These facts are mostly historical, scientific and technical, but some of them have legal and economic bearings.

The science of wireless telegraphy began its experimental career when Hertz showed, in 1888, that electric waves can be made at one place and perceived at another. It is almost as easy as dropping a pebble into a quiet pond and watching the water waves arrive at the other side of the pond. Branly and Oliver Lodge, about 1890, invented a sensitive means of detecting the waves (called the "coherer"), and Lodge, in 1894, transmitted signals and recorded them across a distance of 60 yards. Far-seeing thinkers like Crookes then immediately foreshadowed world-wide wireless telegraphy conducted by aid of tuned apparatus, but offered no practical suggestions. For all we knew, centuries might have passed before wireless telegraphy could be developed to span a hundred miles, although investigations were then in progress in many laboratories.

But among those investigators there was one pre-eminently gifted with faith and insight and inventiveness whose work soon became world famous. Senator Marconi, as we know him now, about 1896, discovered the principle of the earthed aerial.

or antenna, raised Hertz's laboratory work to an engineering scale, and improved the coherer greatly. He thought of and tested innumerable things, selected with uncanny foresight those that were going to be practical, and, in fact, found what still appear to be the only possible paths through the jungle which Nature presents to every investigator and inventor in a really new branch of endeavour. I recall with personal gratification, that after a considerable training in Hertzian waves I joined Marconi's staff about the time he was developing tuning, and was amazed at the way in which high frequency currents were being handled; and although I was with him less than a year I learned sufficient to revolutionise my point of view. During the years between 1896 and 1910, Marconi, aided by Lodge's invention of the tuning coil, carried wireless telegraphy substantially to its present form:—(1) a means of generating electrical oscillations; (2) an elevated conductor (called the antenna) for making electric waves that will spread in all directions; (3) means for collecting the waves at the receiving station —usually an elevated conductor—and (4) means for detecting and making evident the arrival of waves. Meanwhile, other inventors had been at work in nearly every country and had made valuable contributions, but they scarcely deflected the progress of their leader. Poulsen's arc transmitter is the chief of the other contributions. By 1909 the Atlantic had been spanned satisfactorily, and other oceans attempted; in short, wireless telegraphy had grown up in about the same interval of time as was taken by the Watt steam engine.

Indeed, before the end of 1909 the prospect of a fight between the cable and wireless was debated everywhere and the experience accumulated by various governments and companies was such that the feasibility of establishing wireless communication between the parts of our scattered Empire became apparent. In March, 1910, the Marconi Company applied to the Colonial Office for permission to erect a number of large wireless stations for providing communication between the most important parts of the Empire. The matter was passed to the Cable Landing Rights Committee and was also discussed by the Committee of Imperial Defence during 1910 and 1911 In June, 1911, the Imperial Conference passed a resolution that a State-owned wireless chain should be established, and a joint committee was then appointed representing Government Departments, Australia, New Zealand, South Africa and India. This committee, which was called the Imperial Wireless Committee, requested the Post Office to prepare terms upon which negotiations might be opened with the Marconi Company. The terms so prepared were considered by the Cable Landing Rights Committee, who asked the Postmaster General to enter upon the negotiations with the Company.

In July, 1912, an agreement between the Postmaster General and the Company was signed under which the Company was to erect forthwith stations in England, Egypt or Cyprus, Aden, Bangalore, South Africa and Singapore; and others were to follow. The stations were to be capable of maintaining uninterrupted intercommunication throughout the 24 hours and were to work duplex and high speed during a portion of each day. This contract was not ratified by Parliament; a Select Committee of the House of Commons discussed it throughout the winter of 1912-13, and an Advisory Committee presided over by Lord Parker and including several experienced engineers and scientists discussed the technical and the patent aspects of the contract. In consequence a second contract was agreed upon between the Postmaster General and the Company and this was ratified by the House of Commons on the 8th August, 1913. Work began at Leafield in March, 1914, a station in Egypt was commenced a little later, and sites were provisionally selected in East Africa, South Africa and the Straits. But at the end of 1914 and in January, 1915, the Post Office informed the Company that the Government had decided not to go on with the work, and the Company thereupon intimated that they would claim compensation for breach of the contract.

The war was now compelling attention to wireless telegraphy in every aspect. The Admiralty set up a dozen medium power stations at well distributed points of the Empire, the Marconi Company being the contractors. There were many new inventions and many novel applications, nearly all of them improvements of apparatus and methods existing before the war. The chief improvements were in the detail design of the audion and its associated

circuits and these improvements greatly enhanced the practicability of wireless. The audion was introduced in 1907 by the American inventor de Forest as an improvement of the Fleming valve, that is as a rectifier, but became finally a fundamentally different apparatus utilising phenomena that make it a useful magnifier of electric currents. Different makers name it a "pliotron," a "three electrode vacuum tube," a "three electrode lamp," or a "three electrode valve." The official international name is "triode" or "triode valve," but in English wireless slang it is frequently called a "valve." Its essential valuable characteristic is that it amplifies currents. In small sizes it is used for reception and enables very feeble signals to be made audible. In large sizes it is employed for transmission. This is done by taking a portion of the existing oscillation, feeding it to the input side of the triode valve and adding the magnified result to the original oscillation, all in a continuous manner. The energy is supplied from a direct current battery and the magnifying process goes on until a certain limit is attained determined by the sizes of the battery, the triode valve and other parts of the apparatus. This feed back method of strengthening and sustaining oscillations was invented by Armstrong in America and by Meissner in Germany independently in the spring of 1913 and also by Langmuir in America in October of the same year. It enables the triode valve to be used not only as a rectifier and an amplifier, but also as a converter of direct current into current oscillating at any desired frequency.

The war greatly accelerated the development of these pre-war inventions, and nowhere was progress more rapid than in the Radio-telegraphic laboratory of the French Army. Here, under the guidance of General Ferrié, the valve, or lamp, as the French call it, was pushed to perfection in the construction of amplifiers and other apparatus for the reception of signals. The apparatus in use to-day for these purposes remains much the same as at the date of the Armistice. The basic inventions of Marconi, Lodge and Poulsen, have become more and more valuable in consequence of improvements brought about by the triode valve, and in the sending plant as well as in the receiving apparatus.

Meanwhile, although work on our Imperial Chain has been suspended, America, France, Germany and Italy found it necessary to press on during the war with their corresponding schemes. As it stands now, the American Navy's strategic and partly commercial Chain comprises six first-class stations and a larger number of second-class stations. The first-class stations link Washington with Central America and California, and through Honolulu and Guam with the Philippines. The terminal station has a 500 kilowatt arc, and is less than 2,000 miles from Pekin, Tokio, India and Northern Australia. Most of the steps of the Pacific Chain are of the 2,000 mile order, but there is one big step of 4,600 miles, from Honolulu to Guam.

The French Military Chain is now nearly completed, much of it having been planned since the Armistice. Paris is, or will shortly be, linked by first-class stations with the Soudan, the Congo, Antananarivo, Pondicherry and Cochin China. All these steps are of the 2,000 mile order or less, except that from Antananarivo to Pondicherry, which is 3,100 miles. Besides the Military Chain, France possesses a first-class Naval station at Nantes, and two magnificent stations at Bordeaux and Lyons, controlled by the Department of Posts and Telegraphs.

The Italian State-owned scheme embraces two modern stations in Italy, and two spark ones in North East Africa. The Rome station was built by Mr. Elwell during the war, and the Coltano station is being re-equipped by the Marconi Company. The largest distance between the Italian stations is about 2,500 miles. The German Chain contemplated three stations in Africa, one in the Java Seas and one in Yap. Those which were erected were lost during the war. The distance from the Nauen station to the Kamina station is 3,400 miles, and proved too great for real work. Windhuk is nearly 2,000 miles south of Kamina, and is believed to have exchanged scarcely any signals successfully during its short active life.

At the time these various wireless networks were being laid down or completed by foreign Governments, the British Post Office obtained a grant of £170,000 for equipping with arcs the Leafield and Cairo stations, abandoned in the first year of the war, and the Marconi Company brought their long-deferred action for damages for breach of contract and went before Mr. Justice A. T. Lawrence with the Petition of Right. The Arbitrator awarded in July, 1919,

the sum of £590,000 to the Company, as his estimate of the present worth of all the royalties which the Company would have received under the contract.

The Government now decided to take up again the problem of the Imperial Chain. They had before them the advice of the Parker Committee of date 1913, and there was the experience of the war and of other countries. The Parker Report stated that the Marconi Company were, in 1913, the only firm doing business in this country able to erect at once stations of the necessary magnitude; but it added some comments which probably influenced later decisions. The Report (paragraph 9) points out that in order to get the best results it would probably be desirable to "combine apparatus, the combination of which is difficult, if not impossible, because of the existence of patent rights." A notorious example of this mode of operation of the patent system is seen in Watt's "sun and planet motion," and there are innumerable others. The Crown, however, cannot be prevented from using any patent. This is an advantage of State ownership arising out of technico-legal considerations, and may perhaps be regarded as worthy to rank with the political and strategical advantages envisaged by the Committee of Imperial Defence.

But in order to obtain up-to-date advice Lord Milner, as Chairman of the Imperial Communications Committee, and with the approval of the Cabinet, appointed in November, 1919, a committee under the chairmanship of Sir Henry Norman to consider afresh the problem of establishing an Imperial Chain of wireless stations. The terms of reference instructed the Committee to consider both strategical and commercial requirements, and to make estimates of costs and of revenue, under any scheme they proposed. Of the strategical requirements, those of the Admiralty were the most stringent, for they desired quick communication with every naval base in the Empire, and with all ships above the class of light cruiser, wherever they may be at sea between latitude 60° N. and latitude 60° S., either direct or through not more than two linking stations. Clearly this last requirement has a bearing on the Admiralty estimates, for if squadrons can be constantly in touch with headquarters, instead of being lost for days or weeks at a time, fewer ships can do a definite duty. The commercial requirements included the serving of as many communities as possible, the provision of uninterrupted communication at all hours and all seasons, and a large traffic handling capacity. In addition, the scheme should be so economical in capital outlay that it would yield a profit at an early date after interest and amortisation were provided for.

The merely physical problems confronting the Committee may best be described by aid of an analogy. Suppose that a proposal were made to establish telegraphic communication between Hampstead Heath and the Crystal Palace by means of beams of light sent across London. We know that on a dark night with a clear atmosphere, the rays of a single candle would be sufficient to carry signals from either station to the other. But when a thick brown fog hung over the City on a December morning, it would be impossible to pass a signal even by aid of millions of candle power. There are all grades of opacity between these extremes, and, in fact, the candle power found just sufficient for transmission would be different every day. Now, it would be quite true to say of this particular method of signalling between these points, that a telegraphic service was possible with, say, 200 candle power; but everyone knows that at certain seasons there would be good signals only for an hour or two per day, at other seasons for many hours per day, and on rarer occasions a good telegraphic service might be maintained throughout the twenty-four hours. In order to increase the average number of useful daily hours per annum the most natural step would be to set up a relay station—say, on the dome of St. Paul's. The same candle power will pass more messages through the half distance than through the whole distance, and the service would, therefore, be more continuous. The central relay station, would, besides, be able to seize opportunities of any clear intervals that might arise to the north or south of it. The erratic way in which these clear intervals occur in a misty or foggy atmosphere is familiar to every Londoner. It will be admitted that an even better service, reckoned by the average annual hours of effective communication, would be afforded by having more than one intermediate relay station.

All this is but a paraphrase of what occurs on the grand scale in wireless tele-

graphy. Instead of miles we must speak of thousands of miles; instead of patches of fog over parishes we must think in oceans and continents. Instead of the smoky vapours of the Thames we think of electrical fogs extending into the highest atmosphere; fogs that may gather and disperse just as rapidly as the London mists; fogs that have daily and yearly variations as unaccountable as the weather itself.

At this point, the analogy must be dispensed with because there are other electrical difficulties not analogous to the meteorological ones I have just described. For whenever electricity gathers in the atmosphere, electrical discharges from one portion of air to another, or to the earth, are continually taking place, and these generate natural electric waves that course over the earth, agitate the receiving apparatus of wireless stations, and produce noises in the telephone of the operator or marks on the tape of the recorder, which mask or overwhelm the man-made signals. These disturbances, due to natural electric discharges, are spoken of as "X's" or "strays" or "atmospherics." In these circumstances it is of little use to employ powerful magnifiers of the signals enfeebled by passing through thousands of miles of electrical fog, for the true and the false signals are magnified together. The only hope is to discover and apply methods of discriminating between the true and the false; such methods are being slowly evolved.

As an example of what happens on the large scale, consider the reception in India of signals from England. During December, January and February the conditions in India are very brilliant and every message may be letter perfect at high speed during practically the whole of the twenty-four hours. In March the monsoon approaches and reception becomes gradually worse. During April, May and June the monsoon conditions are establishing themselves and signalling results are very bad indeed, but when fully established, as in July and August, signals are rather better. In September the monsoon begins to withdraw and during this month and October many hours may be lost on many days. November is better but is disturbed by bursts of atmospherics; and now the good time of the year begins again.

The Committee had these considerations before them and studied the views of many people of experience in these matters. They concluded that if, for example, direct communication were attempted between England and Australia, there could be only a few hours of good service per day on the average and that the owners of the stations would then call for the erection of an intermediate station in India in order to employ their capital to better advantage. A group of five big stations namely, England, Vancouver, Australia, South Africa and India, is an attractive scheme but is open to similar objections—that is to say the annual average of hours of service might be too low to be remunerative, especially if, as must needs be, the stations erected were to be of the largest possible dimensions. The next step is obviously to introduce intermediate relay stations between the big five and to install at all places first-class stations of great but not extreme magnitude. Spent in this way the same money would give, the Committee believed, a more efficient and in the end more speedy service between the principal centres, would bring the communities at the intermediate places into touch with the rest of the Empire, and would more assuredly satisfy the Admiralty's and the other strategical requirements. This distribution of the stations happens to be geographically possible in the case of the British Empire without exceeding 2,800 miles in any step, the average step being about 2,400 miles. This has become known as the 2,000 mile scheme. It happens to coincide with the length of the step aimed at in the American, French and Italian schemes, though some of these were perhaps settled upon later.

But in order to insure uninterrupted service over distances ranging from 2,000 to 2,800 miles at bad times of the day and year the stations would have to be very powerful. After collecting evidence of what was likely to be practicable within a few years they decided to recommend that the plant be designed to deliver 240 kilowatts to a low resistance aerial of great height. If the art had not sufficiently developed by the time erection was in progress, the stations should be built of 120 kilowatts power and be made capable of early enlargement to the full power. Two methods, the Poulsen arc and the triode valve, were especially favoured and considered. They recommended that the triode valve method of generation of oscillations should be employed, if sufficiently developed. If I

may say so this was a very bold move on the part of the Committee for the largest known valve station in existence at that date was probably less than 20 kilowatts in magnitude.

The action of the Committee has doubtless had some influence upon recent developments of big triode valves.

With such stations, the Committee pointed out in their report, each centre would be able to communicate during certain hours of the day with the most distant of its fellow stations; and they expected that by aid of the intermediate stations any two of the centres could get into communication quickly at any time of day or year. On this point, perhaps, the Committee were a little over sanguine—there will be occasional hours, I imagine, when even the more powerful stations will fail to force good signals across 2,800 miles.

The chain of stations as finally recommended by the Committee for immediate erection, consisted of stations in England, Egypt, India, Singapore, Hong Kong, Northern or Western Australia, East Africa and South Africa. The stations in England and in Egypt are to be of the new type and additional to Post Office stations at Leafield and Cairo. There are thus two branches, an African and an Eastern, meeting in Egypt. The case of Canada was postponed for joint consideration with representatives of the Canadian Government, stations at Montreal and Vancouver being provisionally suggested. In actual operation messages from England to Australia would pass through all the intervening relay stations during the intervals of greatest atmospheric opacity and disturbance, being handled in much the same way as at cable relay stations. During clear intervals one or more of the relay stations would be omitted. Wireless here possesses great advantages over the cable.

The Committee recommended that the Post Office Engineering Department in this country and the corresponding Departments overseas be given responsibility for making contracts with private engineering firms and supervising construction, and further recommended that a small Commission be appointed for planning the stations and advising generally during erection. This, by the way, is in close accord with the principles enunciated by Lord Parker's Committee of 1913 in their valuable Report. The planning commission was appointed by the Cabinet at the end of 1921, about seven months after the earlier Committee had reported. Lord Milner, in his capacity as Chairman of the Imperial Communications Committee, became Chairman of the Commission. During the past year the Commission have acted, when called upon, as advisers to the Imperial Communications Committee, the Dominions and the Indian Government. Their main work has been of the nature of design and selection of the best apparatus and methods of construction of the Imperial stations within the scope of the preceding Committee's recommendations.

It is with warm appreciation of Lord Milner's trust in the Commission that I recall his instructions that we should choose the most suitable apparatus and methods without constraint and with scrupulous impartiality. The Commission's Report, which was completed in December last, was drafted on the understanding that the work would be carried out by private firms rather than in Government workshops. The outline specifications in the Report leave a wide latitude for firms to submit ideas and processes of their own for the approval of the Commission.

The chief anxiety of the Commission during the past year has been to determine whether or not the equipping and running of triode valve stations of 120 and 240 kilowatts is a practical proposition from every point of view. They have been almost satisfied by witnessing the independent development work of the Signal School and of the Marconi Company. There was sufficient doubt left as regards annual running costs to lead the Commission to recommend that arc stations be temporarily installed in the Nairobi, Singapore and Hong Kong stations, to be converted later to valve stations when these had been proved out in less remote places.

The Commission have had to survey broadly the capability of the industry to meet promptly the probable demands during construction and afterwards. Triode valves in glass can be supplied in ample quantity by the Marconi Osram Valve Company; valves in silica and also in glass can be supplied similarly by the Mullard Radio Valve Company. As regards tall masts, the Elwell firm have erected some of the tallest in America and Europe. As to general wireless plant the Marconi

Company have obtained modern experience of large station work at Carnarvon and Coltano; the Elwell group have been responsible for the construction and installation of vital parts of the big stations at Paris, Lyons, Nantes, Rome, Leafield and Cairo, as well as several in America. Altogether there is a great body of experience in private firms available for contributing to the construction of the chain stations.

Over and above this the scientific staff of various Departments of the Government have gained much experience during the war and since. The Admiralty Signal School, Portsmouth, is, I believe, well ahead of any firm in the applications of the large silica triode valve. The transmitter erected at the Horsea Experimental Station at the request of the Commission is able to deliver about 100 kilowatts to an antenna and is probably the largest in the world. The Army, at the Signal Experimental Establishment, have developed a type of high speed receiving apparatus of unsurpassed efficacy. The Post Office, in their Research Laboratory, have devised and developed receiving apparatus which has won the admiration of all who have worked with it in this country, in Egypt, India and East Africa. All these improvements, are, I understand, protected by patents of which the Crown has free user.

No discussion of the Imperial Chain would be complete without a reference to the patent situation. I have already indicated that many of the fundamental things of wireless telegraphy are now free for all to use. The elevated conductor, the tuning coil, the arc converter, various detectors, the two electrode valve for rectifying, the triode valve for magnifying, and others, are as free as the steam engine and are relatively as useful. For example, the great new transmitting station near Bordeaux, owned by the French Government, and perhaps the greatest in the world, is, so far as I am aware, quite free from patents. All the transmitting stations of the American chain appear to be similarly free. On the other hand, some, but not all, of the Imperial Chain transmitting stations will employ the Meissner feed-back invention described earlier in this paper, but I am instructed that the rights of this have been acquired by the Marconi Company and that user of it has been paid for by the Crown in the £590,000 awarded to the Company by Mr. Justice Lawrence. I do not know that any other patent of significance will be employed by the transmitting stations. As regards the receiving stations of the Chain the Meissner patent is again employed (but has been paid for) and the heterodyne patents belonging to the Metropolitan Vickers Company may possibly be held to be concerned. There are two early patents of German origin which may possibly be employed in the Chain stations, one for amplifying oscillations before transmission and another for amplifying the feeble oscillations dealt with in reception, but neither of these is given much weight by the experts in these matters. No other patents of the last class and of outstanding or fundamental importance appear to be employed.

The study of the patent situation leads to a mention of that other kind of monopoly brought about by business and financial combination. Wireless telegraphy lends itself to this type of monopoly very easily, chiefly because there is only a limited number of wave bands available for distribution to powerful stations and there is no room for late applicants. But it appears to me that the way of minimising this danger has been indicated by America and France. These and other nations have established first their State-owned chains, and after thus ensuring the national security and other national interests, have proceeded to give facilities to commercial firms wishing to undertake telegraphic business. The competition in efficiency of two independent schemes, one national and the other private, cannot but be beneficial to both and to the public interest.

I think that the facts I have now laid before you explain why a long succession of Committees and Conferences, including the Imperial Conferences of 1911 and 1921, have all decided that the Imperial Chain should be State-owned. The chief reasons are strategical, political and technical. The strategical point of view needs no emphasis; the political advantage of State-ownership is that only in this way can Empire telegrams be ensured such a measure of priority or preference as will stimulate inter-Imperial trade and foster feelings of kinship. As regards the technical advantages, in the first place the Crown alone can, without fear of injunction, select and combine the best apparatus of rival systems; and in the second place, only the Crown can call upon and unite

the stored knowledge and experience of all the Companies and all the Government Departments in every Dominion. Moreover, only the Crown can do level justice to all the competing private interests.

I must not close without referring to that marvellous feature possessed exclusively by wireless and known as "broadcasting." A wireless station shouts to all the world and wireless is therefore going to share with the Press the moulding of public opinion. When an Imperial news service has been organised, every newspaper office in every Colony will pick up its news by aid of inexpensive receiving apparatus. I venture to suggest to our Chairman, who is President of the Empire Press Union, that the Union have here great scope for constructive organising work. I suggest also, that they could make a good case for the transmission of general press messages at a very low charge per word during those parts of the day unsuitable for the perfect accuracy demanded by coded and high speed private and official messages. But not only that; broadcasted news is intercepted with avidity by the vernacular press in many countries, as Lord Northcliffe has pointed out, and thus by means of the Imperial stations, British national advertisement and other propaganda will take their place in influencing foreign opinion and the flow of trade.

But what will, I think, appeal strongly to the Dominions and Colonies and Indian Sections of this Society, is the fact that anyone who wishes will be able to pick up the news for himself if there is no local newspaper to do it for him. And thus the ranches of Canada, the homesteads throughout Australasia, the settlers scattered from Rhodesia to the Cape and the lonely Englishman in remote provinces of the Indian Empire, will be able to receive the news from London as quickly as can many an English village.

DISCUSSION.

THE CHAIRMAN (Viscount Burnham) said that, as Mr. Balfour used to say, he was a child in those high matters, but he was a child of Fleet Street, and that made him deeply concerned in all Dr. Eccles had told them. He did not know that he was much alarmed by the menace with which the paper terminated. He did not think the broadcasting of news would be much of a danger to the Press as an alternative method of public information. He thought the broadcasting of news would only be effective as handled by the Press, and he hoped and believed they would be equal to the emergency. He still regarded wireless as the greatest wonder of the world. Wireless telegraphy had developed with wonderful rapidity, but not quite as fast as was anticipated by Senator Marconi when he addressed the Imperial Press Conference in 1909, and he (Viscount Burnham) was in the chair then, and told them he would be able to give them a regular and reliable service of news by the autumn. Senator Marconi was only a little previous. Accustomed as they had been of late years to the marvellous advances of applied science, it seemed almost incredible that Marconi's first patent was only taken out in 1896. It was only in that year that Sir William Preece invited Signor Marconi to send messages across the Bristol Channel. Two years subsequently installations were set up between the South Foreland and the East Goodwin light-vessel and the South Foreland and Wimereux in France. The system was largely used during the naval manœuvres of 1899 and definitely adopted by the Admiralty in 1900. It was employed during the Boer War. In 1901 it was already at work on 37 ships of the British Navy; it was part of the regular service of the Governments of Germany and France, and in June of that year the first Atlantic liner belonging to Great Britain sailing between Liverpool and New York was equipped with it. It had already been installed on the Norddeutscher Lloyd mail steamer, Kaiser Wilhelm der Grosse, and even the Germans were making use of it commercially to and fro on ships at sea, and the Belgians with their Princess Clementine found it practicable to communicate to Dover Harbour from La Panne —70 kilometres away; and on more than one occasion, although the S.O.S. signal had not then been thought of, the lives of shipwrecked mariners were saved by wireless messages summoning assistance to their relief. The Prince of Wales was not the first member of his family to be made acquainted with the wonders of wireless, because when the present King and Queen went to Australia, as the Duke and Duchess of Cornwall and York, the Marconi system was used during the voyage. When their son, the Prince of Wales, went to the Antipodes in the Renown, there were many times points on the journey which could only be reached by wireless. It might not be out of place to recall the early efforts of the *Daily Telegraph* to make practical use of the new telegraphy in the interests of meteorology. Scientific experts had placed it on record that the time had arrived for trying the efficiency of wireless telegraphy in providing advanced news of the weather in the Atlantic, and pleaded that there should be no unnecessary delay in organising the practical experiment. The report of the Committee appointed by the then Prime Minister was published in June, 1904. The Editor put himself into communication with the

Marconi Company and the great shipping lines, and on August 6th of that year the *Daily Telegraph* printed the first wireless telegram from the Atlantic, sent by the Allan Liner Tunisian. The first message was actually received on August 4th from latitude 56 degrees N. and longitude 20 degrees W., and was timed noon: a later Marconigram came to hand at midnight and on Sunday at noon a third message from latitude 56 degrees N., longitude 9 degrees W., was received. These messages were despatched at a distance of about 70 miles from the mainland. They were received at Malin and thence transmitted by ordinary postal telegraph lines. The limit of distance was regulated by the transmitting power on board the steamer, but there was no such restriction of power transmission on land and the messages despatched were received on board ship at a distance of 2,250 miles. History had recorded the first attempt to span the Atlantic. It was on Wednesday, December 11th, 1901, that the pre-arranged signal—the letter S in the Morse code—was repeatedly received across the wide expanse of ocean lying between Poldhu and Newfoundland. A kite was used as the aerial. All these early experiments had to do with the sea and not with land. The most confident anticipations were formed of the future use of wireless to and from ships, and these had been more than fulfilled Every night from both sides of the Atlantic news was flashed to be reproduced in the newspapers published on the great liners or in the news bulletins in the smaller steamships: and he might tell them that there was acute competition going on now among the newspapers as to who should supply the wireless that was being used on board the different liners of ships, because, obviously, it had a great publicity value--he might say quite frankly—for advertising purposes The broadcasting of news had become a big business since the Great War, when wireless was of immense service in propaganda. It was still employed for similar purposes, not merely by Governments, but by great trading corporations. Everybody knew that that tendency with the tremendous emulation in advertising values was bound to increase rapidly. Looking back at their own experiments it was interesting to note that every day the Air Ministry compiled its meteorological forecast from wireless reports There was another Press aspect. They often in the days gone by had read their paper in the morning, especially in the winter time, and had to do without the cabled news from some important foreign parts. Well now, of course, wireless competed with the cable, and sometimes one wins and sometimes the other. Repeatedly when land wires, feeding the cables were down during wind storms, the wireless, subject to no such disability, came to the assistance of the newspapers. It was rarely that one had to print nowadays "No news was received last night from Paris, because of the interruptions to the 'Special Wire.'" They all knew that wireless had troubles of its own, but the competition between the cable and wireless gave them of the Press much greater regularity and certainty in the reception of their special news than they ever had before. Every day brought them fresh developments. They knew now that they could have wireless telephones in their homes. Already, as the members of the many distinct wireless societies would tell them, members who had reinstalled their wireless sets might enjoy concerts by wireless for about a quarter of an hour once a week. The time was limited by regulations, which, he took it, were going to be revised. Even then, of course, they would have nothing like the facilities, the embarrassing facilities, which they heard were enjoyed in the United States. They might suffer from what Bismarck called the "spirit of the green table," because regulations often stood in the way of progress. In America government counted for much less and there was no Government control, and there wireless telephony was becoming, it was said, a form of furore. The other day he read of how the police were making use of wireless to draw a girdle around the earth In Paris they did so with a motor-conveyed transmitter in conjunction with an aeroplane it was high time they did so, for not a few fugitives from justice had fled from this country by air express and had been followed by wireless Soon, too, he supposed, every policeman would be a walking "wireless set," in direct touch with all the world The newspapers of yesterday and today were remarkably full of news of wireless developments. There was, of course, the speech of the Postmaster-General in the House of Commons, and although the proposed installation of broadcasting stations was not yet defined, it might include the dissemination of all classes of news. Secondly, there was the promise of secrecy to be obtained by short wave lengths, as explained in a remarkable paper by Mr. Franklin. Thirdly, they were reminded of the frequency, or rather the frequent possibilities, of saving life at sea by summoning doctors to vessels for urgent operations; in the last few weeks there had been a good deal of discussion on this subject; and, lastly, there had been, what he had mentioned, the immediate introduction of wireless into the home for the purposes of family entertainment. They who had been on the prairie could imagine what a tremendous relief that would be to the monotony of life which the settlers in the scattered and far distant parts of the Empire suffered from now. Re-visiting Canada after 25 years he saw what a difference had been made in the life of the prairie farm by the telephone and the motor car. When in addition to that the amenities of wireless were provided, there would not be the same craving perhaps for the movies and the street lamps which prevented so many good Englishmen

making the great adventure with their wives and families on the trackless wastes which awaited cultivation and development all over the English world. He was sure he expressed what they all felt in their hearts when he said that there could be no more important subject for their discussion amd none destined more to change the conditions of human life and profoundly to modify the progress of their civilisation. They were unusually fortunate in the number of men of great knowledge who were there that day, and he was certain that the man they would like to hear first and most was the man to whom they owed so much of the developments that they had been talking about—Senator Marconi.

SENATOR G. MARCONI, G.C.V.O., thanked Viscount Burnham very sincerely for the kind things he had said about the speaker's long connection with wireless telegraphy, and also for the very interesting résumé his lordship had given of the developments of wireless telegraphy during the last twenty or twenty-five years. If progress sometimes had not been quite as rapid as he would have desired, perhaps Lord Burnham would agree that that had not always been the fault of the inventor: other influences had sometimes kept it back. He had always found Lord Burnham most sympathetic, most enterprising, and most ready to test anything that was useful, and to publish and give credit for any good result obtained. In that respect he had been a real friend to the progress of the new art of communication. With reference to the paper, he desired to express his thanks to the author for the kind words he had used regarding his (Senator Marconi's) work in radiotelegraphy. He was glad that a man of such scientific attainments had remained faithful to the fascinating subject of wireless. He could not help, however, disagreeing with the author's views with regard to the limitation of the range of wireless stations, because, in his opinion, there was no range on earth that could not be covered satisfactorily if stations employing adequate power and equipped with suitable apparatus were constructed. As the author had recalled the fact that he (Senator Marconi) had had the privilege of having him as his assistant for a short period many years ago, Dr. Eccles would perhaps agree that reliable communication could at present be achieved over distances which would have seemed to him, as to almost anyone else at that time, very doubtful, if not impossible. The increase in the ranges at which signals could be occasionally received was not so great, since the early days of wireless, as the increase in the ranges at which reliable communication could now be carried on throughout the year. But even now new methods were being developed which, for instance, might cause an entire departure from the current practice in radiotelegraphy, and those methods might differ as much from the methods now in use as the latter did from the arrangements in current use twenty years ago. The author, in explaining the variability in the range of wireless telegraphy, had made an analogy which he did not consider quite fair, namely, the analogy of the transmission of light in a place like London or any other place during clear weather and in foggy weather. A strong light might be seen on a clear day for twenty miles or so, but on the advent of a thick fog that distance might be cut down to one hundredth part, or even less, of twenty miles. But that extent of reduction never occurred in his experience in wireless telegraphy, and if it were the case, at least one hundred intermediate stations would be required between this country and Australia. He did not desire the author to be misunderstood when he stated that the electrical difficulties were much greater than the meteorological ones to which he had just referred. He believed there was no case in which the range of a big station was brought down to one-hundredth or one-thousandth of its working range. It was those facts that made him consider that perhaps the author was more pessimistic than he ought to be when speaking of the possible reliable range of long-distance radiotelegraphic stations. In conclusion, he desired to say that he had listened with the greatest interest to the description given of the schemes for bettering and facilitating communication between different parts of the British Empire and different parts of the world.

MR. ALAN A. CAMPBELL SWINTON, F.R.S. (Chairman of the Council), congratulated the Society on the very interesting paper that had been read, and on the fact of so many eminent and distinguished gentlemen being present to listen to it, a result largely due to the persistence of the Secretary of the Sections, Mr. Digby. The author had referred to the earlier experimental work carried out by Hertz in 1888, but it was not well known that in 1879 Professor David Hughes also made certain very interesting experiments on the subject of wireless telegraphy. He did not publish the results of those experiments, and priority could not, therefore, be claimed for them. Nevertheless, it was an interesting fact that quite recently a number of his notebooks had come into the possession of the British Museum, which he (Mr. Campbell Swinton) was requested to investigate with the object of seeing whether they were of sufficient value for the British Museum to include in its collection. On examination, he found a complete account made by Hughes at the time of all the experiments he had carried out and of the various people he asked to see them. They completely verified the fact that while Hughes thought the result he obtained was due to conduction

through the air, and had no idea that electrical waves entered into the matter at all, Hughes did manage to transmit signals from his house through space over three or four hundred yards; in fact, he carried out practically the same sort of experiment that Lodge made a great many years later. The notebooks showed that Hughes had made a certain amount of apparatus, and he (Mr. Campbell Swinton) having been informed that the notebooks had been rescued from an incredible mass of useless lumber, made enquiries and discovered a room full of Hughes's effects. On looking through them the actual apparatus with which Hughes made his experiments were found, and he was happy to state that the trustees of Mrs. Hughes, to whom the instruments belonged, had presented them to the Science Museum.

Mr. Godfrey Isaacs said he was sure the author would forgive him if, in dealing with a subject of such importance, he did not indulge in idle compliments, but said what he thought about the paper which had been read. In order to get a true understanding of the paper, one had to survey for a moment the whole position in respect of the Imperial chain of stations, as recommended by the Commission. As they knew, Canada abstained, at least for the present; Australia, India and South Africa had all condemned the Committee's recommendations and had resolved upon direct communication. Australia had already joined with private enterprise and entered into an agreement for the provision and working of stations for direct service. In those circumstances one could conceive that it had been thought desirable to put up some defence to the Committee's recommendations which India and the Dominions declined to adopt. The author, therefore, had read a paper with the object of making a plain statement of facts which ought to be in possession of those who wished to form their own opinion. In order that everybody might be in a position to form his own opinion, it was essential that the facts he had before him should be accurate. Personally he was afraid that the information with which the author had been furnished had led him into errors which might also be misleading to those who heard or read the paper. One would be led to suppose that America and France commenced by erecting wireless stations for commercial services which would be run by the State, the Governments then granting licences to private enterprise for auxiliary services. That was not the fact. In America wireless telegraphy was free to all. Any American subject might obtain a licence; erect a wireless station; conduct telegraph services, and the American naval stations could not compete with those services. When, in 1920, the Navy Department desired to use their stations for commercial services, the matter was dealt with by the Senate, and the Act which had been passed laid it down that "the right to use such stations for any of the purposes named in this section shall terminate and cease as between any countries or localities or between any locality and privately-operated ships, whenever privately owned and operated stations are capable of meeting the normal communication requirements between such countries or localities or between any locality or privately owned ships and the Secretary of Commerce shall have notified the Secretary of the Navy thereof." That was a totally different position to that which one would gather from the paper. And what about France? The French Government decided that commercial wireless telegraphy could not be efficiently conducted by the Department of Posts and Telegraphs, and it had, therefore, entered into an agreement with the Compagnie Générale de Télégraphie sans Fil, under which the Company was to erect stations and to conduct all the commercial services of France, not only with foreign countries, but also with the French Colonies. Therefore, neither Government had adopted the "2,000 miles order." The author told them that the American Government stations communicating between Honolulu and Guam spanned a distance of 4,600 miles, and that the French Company were erecting stations to communicate with Saigon, Antananarivo and Brazzaville, which were at distances of 10,000, 9,000 and 6,000 kilometres respectively. He was surprised, too, that the author had not mentioned the telegraph services being conducted by the Radio Corporation of America between Honolulu and Japan—3,375 nautical miles. In speaking of the German stations erected before the war, the author said it was believed that it was doubtful if any successful signals were exchanged with Windhuk, which was 5,000 miles from the Nauen station in Germany. He did not know with whom the author meant there existed that doubt. He thought the Services would tell him that when the Germans required, at the outbreak of war, to communicate with Windhuk and their other far-distant stations, they had been so successful in doing so that even prior to our having knowledge in this country that war had been declared, communications had been received by each of their colonial stations advising all their Mercantile Marine of the declaration of war; and in consequence of those messages having been so efficiently received the Germans were able to save practically the whole of their mercantile marine from capture. Speaking, by the way, of the German chain, the author stated that it comprised three stations in Africa, one in Java and one in Yap, and that those stations were lost during the war. He was sure the author would pardon him if he reminded him that Java was in the Dutch East Indies and that the station there was not in existence prior to the war. It had only been constructed since, and belonged to Holland, not to Germany. The Telefunken Company were building a

station in Holland in order to communicate with Java. It would be recognised from the facts he had just given that foreign Governments were not of the opinion that a service should be limited to the "2,000 miles order." None of the principal wireless telegraph companies of the world were of that opinion either, and it must be borne in mind that it was the commercial companies who had the assistance of the ablest experts and those who alone had had practical experience in long-distance commercial services. The Radio Corporation of America (with which was associated the General Electric Co., of Schenectady, the Westinghouse Company, the Western Electric Company, the Thomson Houston Company and the Bell Telephone Company), the Telefunken Company of Germany (which was connected with and had the assistance of the A.E.G. and Siemens and Halske) the Compagnie Générale de Télégraphie sans fil of Paris (which was connected with the big French electrical industries), and the Marconi Company, with all its associated companies, were all convinced of the efficiency and economy of services over long distances. So much was that their opinion that they had joined together in the construction of stations in South America to conduct direct services with the United States, France, Germany and, if the necessary conditions were forthcoming in this country, with England. Direct services with Peking and Japan were also under consideration. The Japanese were very satisfied with their experience in long-distance telegraph services and were desirous of joining with the four great wireless companies in opening up certain long-distance commercial wireless telegraph services. The Commission, for which the author had been speaking, stood alone in the world in still upholding its recommendation in respect of stations of the "2,000 miles order." That was all he proposed to say in reply to the author's defence of the station of the "2,000 miles order." He would like, however, to ask indulgence for a few moments longer to reply to what the author had said upon the subject of patents. Whilst he quite agreed that the patent question was very much allied to the question of the Imperial chain of stations, nevertheless, he felt that the author had been badly advised in dealing with that subject in the way he had in his paper, for it seemed to him to make a most damaging attack upon a great British enterprise which it was his duty to defend. The author said: "I am instructed that the rights of the Meissner patent have been acquired by the Marconi Company and that user of it has been paid for by the Crown in the £590,000 awarded to the Company by Mr. Justice Lawrence." He noticed that the author used the words "I am instructed," and personally he was quite convinced that Dr. Eccles would not have said that of his own accord, for he did not believe for one moment that the author was expressing his own opinion. It was, nevertheless, a very serious statement to have made in his paper, bearing in mind that he had been listened to by a very important and influential audience and that his paper would probably go forth to the world and be published broadcast. It was material to the Marconi Company, and also to prevent the Dominions being misled, that he should dispose of that extraordinary contention. First of all, he would like to ask the author if he had been instructed that in September last the Post Office had been given notice of six patents which were being infringed at the Leafield Station — a matter which was still "receiving consideration." It was difficult to conceive that anybody could hold the view that because the Marconi Company was awarded damages for a breach of contract, on that account, they should have rights—what rights nobody had yet attempted to define—to use the Marconi Company's patents—what patents or for how long equally remained undefined. He might say, however, that so far no such contention had been put forward formally.

Mr. Godfrey Isaacs then proceeded to read the observations made by Mr. Justice Lawrence before handing down his Award, and the terms of the actual Award, in which he stated there was not a word which gave to the Post Office any rights of the kind claimed. It did nothing more than define the amount of damages they must pay for breach of a contract. After quoting the opinion of two of the most eminent King's Counsel, whose opinion the Marconi Company sought directly it was verbally stated to them that such a contention might be raised, Mr. Godfrey Isaacs said that he was quite satisfied to leave it to those present to form their own opinion upon the statement of the facts as to whether damages for breach of contract could possibly provide anybody with right under an agreement, which agreement had been rescinded years ago. The author stated, quite rightly, that the Government had power to use any patents it pleased, but it must be remembered that the very Act which gave the Government that power provided that the subject should have the same recourse against the Crown as it had against the individual, and that if terms could not be arrived at by agreement one had the right of recourse to the Courts. The Meissner patent and all other German, French, American and Marconi patents were the property of the Marconi Company in the whole of the British Empire, and wherever those patents were used, whether it be at Leafield or across the oceans, fair and proper remuneration, according to the value of those patents, must be paid. We were not Bolshevists in this country, and private property could not be seized without due compensation being paid. If that order were ever to change there would be an end to all private enterprise and the ruin that Communism had brought about elsewhere would reign in this country.

LIEUT.-COLONEL W. A. J. O'MEARA, R.E., C.M.G., M.I.E.E., said he had been much interested to learn of the progress that had taken place on the technical side of wireless telegraphy and its proposed application in connexion with the Imperial Wireless Communication scheme, but he confessed that he was disappointed at not having heard anything connected with the progress of the Imperial organisation to carry on that scheme. It was no good projecting schemes unless at the same time an organisation was formed to carry them on. He had learned during the discussion that the Empire was not in accord on the Imperial communication scheme, the reason for which he made bold to say was because the proposed organisation for conducting the service was not suitable for dealing with it. He gathered that Lord Milner's Committee was simply an Advisory Committee which might be called in when it was wanted, and was not used when it was not wanted. When its advice was likely to be acceptable it might be called in; when not it would not be appealed to. That he considered a most unsatisfactory state of affairs if it was desired that progress should be made. The scheme could not be looked upon from the purely parochial point of view that it was a Post Office matter, and he feared the reason that no progress had been made was due to that cause. In his opinion the Post Office organisation was not a suitable one for dealing with such a vast scheme. It was an Empire scheme which required an Empire organisation to carry it on, containing representatives from the Dominions and Colonies affected. The author had given particulars of how the scheme could be carried on and of the progress being made in the Signal Corps and in the Royal Navy. Personally he suggested that the scheme primarily was a strategic one and that it should be run by the Army, the Navy and the Air Force, and that they had technical and administrative personnel competent to deal with it. In his opinion the Post Office had too much on its hands already. He did not know whether any minute had been sent to the Postmaster General pointing out what the recommendations of the Select Committee on the Telephone Service relating to the re-organisation of the Post Office meant, but if he read the remarks of the Postmaster General in the House of Commons of the previous night correctly he (the Postmaster General) had misrepresented the recommendations of that Committee. He mentioned that because wireless was entirely a scientific matter, and if the organisation of the Post Office could not deal with the Report of the Select Committee in a scientific spirit and way, that alone condemned the Post Office organisation. Wireless was not ordinary wire telegraphy; it dealt with an entirely different set of phenomena, and required differently educated and trained people to handle the service. He emphasised that if the scheme was to be carried through an Imperial organisation was necessary.

THE RIGHT HON. SIR HENRY NORMAN, Bt., M.P., thought the Chairman had called upon him because he knew that he would be perfectly safe in trusting him to switch off the discussion from the atmosphere of acute controversy into which it had been plunged to one more in accord with the scientific traditions of the ancient hall in which the meeting was being held. It afforded him the greatest pleasure to move that the thanks of the meeting be accorded to the author for his learned and most interesting paper. He was personally qualified to move the resolution, because few persons, if any, were more able to appreciate than he the public services which Dr. Eccles had rendered. He had had the privilege and great advantage of working with him for a considerable period of time in connection with many subjects and had learned that he was a man of profound knowledge, which was only exceeded by one other quality, namely, his modesty and his willingness to put his great learning under all circumstances at the service of those who were desirous of knowing and were less gifted than himself. Nothing was more discussed at the present day than the subject of wireless telegraphy. It was impossible to open a paper without seeing fresh arguments about it. It was impossible to open a technical journal without running head first against the age long controversy as to who was the original inventor of wireless telegraphy. He had no hesitation in saying that, in the opinion of all who knew, an opinion which history would certainly confirm, no man had rendered greater services in transmuting what was originally a beautiful and academic laboratory experiment into a great service for the inestimable benefit of mankind than Senator Marconi. Wireless had made progress of extraordinary speed. It seemed to him as if it was only yesterday that he succeeded in passing a wireless telegraphic signal from one end of a bench in his workshop to the other, and yet at the present time signals could be sent from this country to Australia; and he remembered how proud he was when he first succeeded in hearing the signals from Clifden, which was at that time the great wireless station. He also recollected during the comparatively early days of the war, when he was a scientific liaison officer between England and France, receiving an urgent message from London to supply the English services with 24 French valves, similar to the ones that the author had exhibited, the request being accompanied by a private letter from the authority instructing him if possible to buy 24 valves; if they could not be bought to beg them, if they could not be begged to borrow them, and if they could not be borrowed to steal them. When it was thought impossible that wireless could go any further, suddenly the announcement was made

in the House of Commons that the country was to be presented with a new development in the shape of broadcasting. Before long every household would be able to listen to music and songs and instructive entertainments by Sir Harry Lauder and Mr. George Robey, and to a sermon on Sunday mornings, while stories would be told to the children at bedtime. In fact it was highly probable that in the future the telephone would be carried to the side of the cradle, and the youngest member of the family would be hushed to sleep by a lullaby sung by Miss Clara Butt! While the members of the House of Commons were a little amused and somewhat sceptical at his remark that they would address their constituents at the next election—if it was postponed for some time—by wireless telephony, they had overlooked the fact that if they addressed their constituents by wireless they would at any rate be relieved from the attention of hecklers! It afforded him the greatest possible pleasure to move the resolution.

Sir Thomas J. Bennett, C.I.E., M.P., in seconding the motion, desired to couple with it an expression of thanks to Lord Burnham for his kindness in presiding over the meeting. The way in which the Chairman filled every post he was called upon to occupy was a marvel almost as marvellous as wireless. There was no man in the public life of England who "moved up to his bit" as Lord Burnham did, and he thought of suggesting to the Secretary that his Lordship should be asked to preside over the meetings of the Society more often than he had done in the past.

The resolution of thanks to Dr. Eccles for his valuable paper and to Lord Burnham for presiding was then put and carried unanimously.

Dr. W. H. Eccles after thanking those present on behalf of Lord Burnham and himself, for the very cordial manner in which the resolution had been passed, said the present was not the time nor the Royal Society of Arts the place to reply in full to the comments that had been made by Mr. Godfrey Isaacs. He would like to say, in reply to Signor Marconi, that a great deal of controversy about the relative strength of signals still occurred because such poor methods of measurement were available. He had recently received from the Naval Laboratory at Washington a chart of measurements in which the strength of signals varied more than 200-fold from 10 o'clock on one morning to 10 o'clock the next morning; many who had been connected with wireless telegraphy from the beginning did not realise those huge variations. He thought that Senator Marconi himself had not perhaps measured them up carefully hitherto. With regard to Mr. Godfrey Isaacs's comments, he felt he would not be thought unfair if he said that Mr. Godfrey Isaacs's statement was an *ex parte* one. The suggestion that the Dominions and India had withdrawn from participation in the chain scheme was new to him, and made him think that the wish was parent to the thought. The suggestion that had been made that the paper had been prompted by someone within the Government was very wide of the mark. As a matter of fact he had rather feared that it might cause offence within Government circles for him to have accepted the invitation of the Royal Society of Arts without express permission from his Chairman. The naval stations of America that had been mentioned closed down their commercial traffic as soon as other facilities were provided, but he thought commercial traffic was still proceeding on the Pacific coast at the naval stations between California and Alaska. The statements that had been made about the French Government and its relations with the Compagnie Générale were quite correct, and he did not think anything he had said was in conflict with them. He did not know, however, that any official statement had been made on the part of the French Government that the Bordeaux station and the Lyons station belonging to the French Post Office were to be handed over to a commercial company or to be closed down for commercial work. On the contrary, to the best of his information they had settled down permanently to commercial work. The statement of Mr. Isaacs that Windhuk and other stations received signals which enabled Germany to save much of her shipping reminded him of the old confusion that arose about communication between two stations to and fro and reception at one. Any installation in a ship at sea could receive from the great station at Nauen, but that was not what he meant when he said that communication was not established between Windhuk and Nauen. No signals from Windhuk were ever received efficiently at Nauen. In that connection he spoke with the authority of the engineers of those stations, who had published in full an account of their work before the war and during the war. He was sure he would be excused from comment at the moment on matters regarding patents and the Lawrence Judgment. They were legal rather than technical matters, and the opinions he had given in the paper were the considered views of the highest authorities in the land on the legal side, which he believed had been in the possession of Mr. Godfrey Isaacs for many months.

The meeting then terminated.

GAMBIER*

Plantation.

Gambier is planted from seeds in nurseries until the plants are 4 to 5 inches high when they are planted out 6 to 10 feet apart.

A gambier estate is generally spread over a large area, in which there are patches of

*Extracted from "Notes on Sarawak Trade," published by the Committee for Agricultural and Forest Exhibits, Malaya-Borneo Exhibition.

planted ground and the estate usually aggregates 70,000 bushes; in addition to the planted area large timber reserves are necessary to supply firewood.

Gardens are weeded twice a year by hand until the young plants are two years old, after which period they are weeded by hoe

Gambier is prepared from the leaves and young shoots of the bush, which are gathered every six months after the second year. The 70,000 bushes are attended to by seven men, including those engaged in the preparation of the gambier; of these seven men, two are employed weeding, two gathering, one procuring firewood, one in charge of the cooking process and one general coolie; the work is extremely hard and scale of wages low, especially when the gambier market is low, when it is customary to reduce wages.

If a plantation is not worked regularly the plants are ruined, so gathering takes place even if the price of gambier is so low that the owner incurs a loss on the manufacture. When gathering does not take place regularly the leaves turn red, the young shoots harden and production of young shoots ceases

Cutting the leaves commences at daylight and continues until 8 o'clock, the weeders assisting the gatherers in bringing the leaves to the factory; at 10 o'clock the gatherers have to go out for leaves for the afternoon cooking, returning about 1 p.m. These gatherers do not assist in the cooking process although they cut the leaves with choppers to prepare for cooking. About 3½ piculs of leaves, etc, are gathered at one time.

Leaves on the main stem are taken first, then the leaves and shoots of the side branches, leaving the upright shoots to produce future supplies.

Harvesting from each takes place once in six months, the gatherers moving from patch to patch of planted area over the whole Estate; some of these gardens are often two miles from the factory.

Factory.

The gathered leaves and shoots are taken to the factory, chopped up, and put into a large copper, which has sides built up with wood, set over a large furnace fed by firewood.

The cuttings are boiled for three hours, being continually turned over with a special wooden instrument having five long prongs; when cooked they are removed by means of a large three-pronged fork and put into a trough (jalor) above, which is set at an incline towards the cooking copper; after the larger leaves have thus been removed the smaller broken pieces are strained by means of a rattan strainer. The cooked leaves, etc., are washed with cold water; the first washings, still of a dark brown colour, run back into the cooking apparatus; the weaker washings are led off through a small trough into a receptacle fixed next to the main copper. These weak washings are transferred to the main copper for the next washing, the new leaves, etc., being added to it.

The liquid in the main copper is now cooked for a further two hours, after which it is removed to small tubs to cool.

If this liquid is left to cool the gambier will not solidify; in order to attain this result a short stick is inserted into the tub at an angle and coolies immerse their hands in the warm liquid and rub up and down the stick with a spiral motion until the colour of the liquid becomes lighter. During this process it thickens; after the liquid has been "worked" for about 15 minutes it is left, and when quite cold is of the consistency of cheese.

When it is quite cool the gambier is removed from the tubs and cut up into sections after which it is dried in the sun for one day and then placed in the rafters of the factory for smoking.

Cube Gambier.

After cooking, the liquid is put into tubs as before, and about 4 tahils of rice bran, which has previously been fried and passed through a sieve, is added; this mixture is "worked" as before and just before becoming solid it is poured into a mould made of wood. The mould is set on a mat and on all inside casings of it are lines to mark the moulded gambier ready for cutting. When the gambier is set, the side of the mould is opened and the block is cut up into cubes by means of thread.

The wet cubes are placed in a bamboo tray and left to dry for one day, after which they are placed in the rafters of the factory to be smoked; this process takes about nine days.

THE NIPA PALM.*

This palm grows in abundance in the mud on the banks of all the rivers of Sarawak, near the coast. It differs from other palms in that it has no trunk, being merely a collection of leaf stems proceeding from a central "stem."

Amongst its many uses the following are perhaps of interest. From the "stem" salt is produced. It is also used as floats of timber rafts; native fireplaces in cases of emergency. When found floating, rotten, in the stream it is collected by natives, dried, made into a fine powder, and used for the treatment of wounds; it is said to be very efficacious. The skin inside the base of the leaf stems is used extensively for making boat balers. The leaf stem itself is sometimes used for flooring and attap ribs. The heart is eaten as a vegetable.

The mature leaf is made into atap for roofing houses and generally as wrappers (tampin), especially for lime and sago.

The leaf ribs are used for making brooms, stands for cooking pots, in the manufacture of atap, baskets, etc., and also the split ribs are

*Extracted from "Notes on Sarawak Trade," published by the Committee for Agricultural and Forest Exhibits, Malaya-Borneo Exhibition.

frequently used in the place of string or rattan. The flower is made into a preserve. The fruit, when young, is also made into a preserve and when old is used instead of betel nut. The husks of the fruit are used for brushes. From the sap from the stem of the flower or fruit sugar and vinegar are obtained.

Nipa Sugar.

A suitable site having been chosen the worker builds a small house (langko) and proceeds to clear the area he intends to work, cutting away the old dead branches and undergrowth.

At the same time he prepares two fireplaces upon which are placed two large cauldrons, and collects firewood; then he prepares 200/300 lengths of bamboo about 1 foot long and 3 ins diameter, which, together with the knapsack, knife, parang, and axe, complete his outfit.

The first two days are spent in peeling the outer skins from the flower stalks and bending them until they droop, the flower is then cut off and the bamboo placed under the end of the stalk to collect the sap which exudes therefrom; this is done in the evening and the bamboos containing the sap are collected early the next morning—sometimes the bamboos are completely filled but generally they are not more than half full of sap.

While collecting, the worker cuts a thin slice from the end of the stalk to prevent it from drying up; during the day the sap runs to waste, interference from bees, hornets and monkeys making it impossible to work.

In the evening the bamboos are set as before and another thin slice cut from the end of the stalk. This process continues about 4 months, from August to December, until it is no longer possible to work the stalk.

The bending of the fruit stalk is considerably more difficult than in the case of the flower stalk, the process occupying about 1½ months instead of two days. The yield and quality are the same in both cases, but the fact that so few workers understand the latter method explains the reduction in output from January to August

It is estimated that two-thirds of the total output is produced in the 5 months when flower stalks are worked.

Preparation.

The bamboos containing the sap are collected in the early morning and carried back to the worker's house in his knapsack at about 9 a.m.

The sap contained in the bamboos is poured through a strainer into the cauldrons, where it is cooked until it boils; then, to prevent waste by boiling over, a circlet of bark is fitted around the inside of the cauldron. This circlet is about 3 feet high.

The empty bamboos are placed upside down on a platform above the fire to dry so that they shall remain sweet and clean.

After about 5 hours the sugar is cooked and the cauldron removed and placed in a hole in the ground, prepared to receive it: it is then stirred for about an hour with a long handled ladle made of cocoanut shell and poured off into tins or jars when it is ready for market.

Two hundred bamboos of sap will produce 3 gallons of sugar the present price of which is $1.20 per 4 gallon tin.

Nipa Vinegar.

The froth from the boiling sugar put into jars and kept for 2 or 3 days becomes vinegar.

Nipa Salt.

This is made from the old stems of the palm. These are cut down and thrown on to a wood fire and burnt till nothing but ashes remains.

The ashes are collected and put into deep baskets and set over an empty boat which has previously been divided into separate watertight spaces. Water is then poured on to the ashes and, filtering through them, drops into the spaces prepared for its reception. The filtering process is continued till the resulting mixture is of such a density that the fruits of the rattan will float on the surface.

The mixture is now poured into vessels made from the sheath of the nibong palm and boiled A narrow trench serves as a fireplace and the cooking pots which are about 1′ x 4″ are laid cross-wise and a wood fire made underneath. As the water boils away leaving a deposit of salt on the sides of the vessel, more of the mixture is added till finally the whole contents become solidified. The cooking process generally lasts for about 6 or 7 hours. The contents of one vessel are worth at present prices about 25 cents.

PRODUCTION OF PINE TIMBER IN SOUTH-WESTERN FRANCE.

One of the most important sources of wealth in south-western France, ranking next to its vineyards and its naval stores, is the timber produced from the maritime pine. The following table shows the forest area of the Departments in south-western France and the area of maritime pine found in these Departments :—

Departments.	Total area.	Area covered by forest.	Area of maritime pine.
	Hectares.	*Hectares.*	*Hectares.*
Charente-Inférieure	682,556	81,670	11,100
Dordogne ...	918,255	255,778	8,300
Lot	521,174	108,616	900
Gironde ...	997,988	461,915	299,200
Lot-et-Garonne	536,011	81,278	39,500
Landes	932,277	516,608	462,400
Total ...	4,588,261	1,505,865	821,400

Hectare=2.471 acres.

It will be seen that of the total forest area of 1,505,865 hectares, 821,400 hectares, or about 55 per cent., is covered with maritime pine.

The various kinds of timber produced from the maritime pine, and the average annual production of each, are as follows:—

	Cubic Metres.
Carpenters' and joiners' timber and wood paving blocks	300,000
Flooring planks	250,000
Planking for export to Spain	150,000
Packing-case timber	215,000
Railway ties	210,000

These figures show a total annual production of 1,125,000 cubic metres of sawn timber from the maritime pine. In addition, the maritime pine produces an annual yield of other products as follows:—Mine supports, 773,000 cubic metres, consisting of 750,000 cubic metres of peeled pit props and 23,000 cubic metres of unpeeled pit props; telephone and telegraph poles, 9,000 cubic metres; firewood, 364,000 cubic metres. There is, therefore, a total yield of 2,578,000 cubic metres of timber annually from the maritime pine of south-western France, which represents an average annual yield of 3.14 cubic metres per hectare.

According to a report by the United States Vice-Consul at Bordeaux, unpeeled mine supports form one of the principal exports from the ports of Bordeaux and Bayonne to Great Britain, where they are used in the coal mines. The average annual exports of unpeeled mine supports to Great Britain for the years from 1914 to 1920 amounted to 640,000 metric tons. In 1920 alone exports of mine supports to Great Britain amounted to 776,000 metric tons, valued at £2,800,000.

Peeled mine supports are used principally in France's own coal mines, particularly in the Departments of the Tarn and Aveyron. Most of these peeled mine supports are furnished by the Departments of the Gironde, Landes, and Lot-et-Garonne, but the two Departments of Lot and Dordogne, which are nearer to the mines, produce peeled pit props in smaller quantities. Owing to the rise in railway rates, however, a production in the three Departments first mentioned, which are at a comparatively greater distance from the French mines, has lost its stimulus and has fallen from 4,000 tons in 1914 to 1,000 tons.

THE SEAWEED INDUSTRY IN HOLLAND.

The harvesting of seaweed and its preparation for commercial use form an industry which has attained importance in the Amsterdam district during the last few years, according to a report by the United States Consul in that city.

At the northern extremity of the Zuider Zee and in its easterly extension, called the Wadden Zee, between the mainland and the chain of islands extending towards the German coast, seaweed grows abundantly in an area some three miles in circumference. The soil of that place happens to be peculiarly adapted to seaweed, which can thrive only in soft and somewhat muddy ground.

At the locality in question, the water is relatively shallow, and at ordinary high tide the bed out of which grows the seaweed is not more than five feet under the surface.

In order to obtain the best quality for commercial use, the seaweed is mown from June to August. It is mown with scythes, as it grows straight, and its top nearly reaches the surface of the water. The mowers work when the tide is low, standing in the water, but clothed in a water-tight garment reaching to the shoulders. Formerly one scythe was used at a time, but now several are fixed to a line, which the workers draw to and fro like a saw above the base of the weed. The product is spread out on adjacent fields to wither in the sun. When it becomes black, it is placed in ditches to soak in water. The fresher the water the blacker the weed turns, and the blacker it is the higher becomes its price. After a few days in the ditch the weed is again spread on the field, and when thoroughly dry is taken into warehouses, where it is made up by means of a press into bales of about 100 pounds each, ready for market. Seaweed harvested in the late autumn is left in the ditch all winter.

Formerly, no restrictions controlled the mowing and marketing of the seaweed, which resulted in over-production and a decline in price, which made the business unprofitable. The Government, therefore, decided to lease the weed lawns to the highest bidder. Two wholesale seaweed merchants secured the lease at an annual rate of 30,000 florins (florin = 1*s.* 8*d.* at normal exchange). However, this did not work satisfactorily, the result being that the municipality of the island of Wieringen was granted the right to deal with the seaweed, and this arrangement has proved satisfactory to all concerned. The municipality fixes the price of the weed, which is from 8 to 15 florins per 100 kilos.

There is also a "fished" seaweed, which is said to be much inferior to the mown. It is caught along the dykes by hooks. Its price is usually 3 or 4 florins per 100 kilos.

The fully prepared seaweed is chiefly used as filling for mattresses and the like. But during the past 20 years many experiments with seaweed have been made in the Netherlands, during which, it is stated, some fine qualities of gelatin were produced.

The exports of seaweed from the Amsterdam district aggregate from 2,000 to 3,000 tons annually, going chiefly to Belgium, England and France, with occasional shipments to the United States. The total annual product of the weed lawns is not stated, but it is understood that much the larger part is used in the home trade. The industry employs several hundred people.

GENERAL NOTES.

Tea Oil Production in China.—China is the only country which produces tea oil in large quantities, according to a statement published by the United States Bureau of Foreign and Domestic Commerce. Japan has a small production, and French Indo-China and India make from the *Camellia drupifera* an oil that is used by the natives as a medicine. The largest producing district in China is in eastern Kwangsi and southern Hunan. Wuchow, near the Kwangsi-Kwangtung boundary, is the principal collecting and exporting centre of the country and annually accounts for more than half the total exports from China. Hankow is the next largest shipping port, the oil being collected from Hunan, Hupeh, and especially from Szechwan. Kiangsi Province is a larger producer of tea oil, but its exports are small, as most of the output is consumed in the Province. Canton, Foochow, and Changsha all make fairly important shipments, and small quantities are exported from Shanghai, Ningpo, Wuchow, Amoy, Swatow, Kowloon, and Nanning. Santuao had a share in the export trade until 1919, when shipments stopped altogether.

Marble in the Isle of Pines.—A large deposit of marble is being successfully developed near Nueva Gerona, Isle of Pines, by a Cuban company, recently put under American management, writes the United States Consul at Nueva Gerona As a result of the recent installation of modern appliances, it is expected that when the plant is in full working order over 3,500 square yards per month will be produced. Hitherto the marble has all been marketed in Habana, but the new management will endeavour to place future production on the market in the United States.

Kaolin Deposits in Finland.—Investigations concerning the extent of the kaolin deposits in Puolanka (Finland) were carried on during the summer of 1921, writes the United States Consul at Helsingfors, with apparently very favourable results. It has been ascertained that there are at least 10,000 tons, and a calculated probability of more than 500,000 tons. Kaolin has been found also in four different places in Pihlajavaara. The deposits are 4 to 6 metres deep; in some places the stratification is over 10 metres deep, and it has been noticed that the deeper stratification furnishes the better kaolin. According to German experts, this kaolin is of excellent quality, clearer and better than elsewhere in Europe; and the china made from it is entirely white. Besides kaolin, red and yellow ochres have also been found at Pihlajavaara; but, although of good quality, they will probably be of little economic importance owing to the cheapness of their products.

MEETING OF THE SOCIETY.

Indian Section.

Friday, June 23 (at 4.30 p.m.)—F. W. Woods, C.I.E., late Chief Engineer, Irrigation Department, Punjab, "Irrigation Enterprise in India." Lord Lamington, G.C.M.G., G.C.I.E., Governor of Bombay, 1903-7, in the chair.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Monday, June 12 .. University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Prof. Dr. A. A. H. Van den Bergh, "Injurious Agents and Growth."

Royal Institution, Albemarle Street, W, 5 p.m. General Meeting.

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5 30 p.m. Two papers by Dr. H. Chatley and Mr. A. S. E. Ackermann, "The Physical Properties of Clay."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Miss A. M. Hodgkin, "The Witness of Archæology to the Bible."

Geographical Society, 135, New Bond Street, W., 8.30 p.m.

Tuesday, June 13 .. University of London, at Gray's Inn Hall, W.C., 4 45 p m. The Hon. J. M. Beck, "The Nature of American Institutions and their Bearing on International Relations." (Lecture I.)

Anthropological Institute, 50, Great Russell Street, W.C., 8 15 p m. Professors G. E. Smith and J. I. Hunter, "A Re-construction of the Piltdown Skull"

Photographic Society, 35, Russell Square, W.C., 7 p m Mr. F. T. Usher, "Matt Surface Plates."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C, 8.30 p m. The Hon. W. G. Ormsby-Gore, "British West Indies."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. Maurice Thiéry, "Le Théâtre de Brieux."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p m. Prof. Paul de Reul, "The Centenary of Shelley."

Zoological Society, Regent's Park, N.W , 5 30 p m. 1. The Secretary, on "The Council's Scheme to establish an Aquarium in the Society's Gardens" 2 Miss Joan B. Proctor, "A Study of the Tortoise *Testudo loveridgii*, Blgr, and the Morphogeny of the Chelonian Carapace" 3 Mr J. T. Carter, "A Microscopical Examination of the teeth of the Primates." 4. Mr. H G Jackson, "A Revision of the Isopod Genus Ligia (*Fabricus*). 5. Mr. W R. B Oliver, "A Review of the Cetacea of the New Zealand Seas." 6. Prof. Wood Jones, "The Dental Characters of certain Australian Rats"

Asiatic Society, 74, Grosvenor Street, W., 4 30 p m. Brig-Gen. Sir Percy Sykes, "The Achæmenian Dynasty."

Wednesday, June 14 .. Microscopical Society, 20, Hanover Square, W., 8 p.m. 1. Mr. J. Strachan, "The Microscope in Paper Making." 2. Mr. A. C. Chapman, "The Use of the Microscope in the Brewing Industry."

Geological Society, Burlington House, Piccadilly, W., 5 30 p.m.

British Academy, at the Royal Society, Burlington House, Piccadilly, W., 5 p.m. Dr. C. Singer, "Leonardo da Vinci as an Anatomist, with special reference to his Mediæval Sources."

Thursday, June 15 .. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Lt.-Col. A. Ogilvie, "Some Aspects of Aeronautical Research." (Wilbur Wright Memorial Lecture.)

University of London, at King's College for Women, Campden Hill Road, W., 4.30 p.m. Prof. V. H. Mottram, "Metabolism of Fat and Allied Substances." (Lecture VIII.)

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Prof. C. H. Reilly, "Some London Streets and their Recent Buildings."

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m.

Journal of the Royal Society of Arts.

No. 3,630. VOL. LXX.

FRIDAY, JUNE 16, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

FRIDAY, JUNE 23rd, at 4.30 p.m. (Indian Section.) F. W. WOODS, C.I.E., late Chief Engineer, Irrigation Department, Punjab, "Irrigation Enterprise in India." LORD LAMINGTON, G.C.M.G., G.C.I.E., Governor of Bombay, 1903-7, in the chair.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One hundred-and-Sixty Eighth Annual General Meeting, for the purpose of receiving the Council's Report and the Financial Statement for 1921, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 28th, at 4 p.m.

(By order of the Council)

GEORGE KENNETH MENZIES,

Secretary.

SOCIETY'S ALBERT MEDAL.

The Albert Medal of the Society for the current year has been awarded by the Council, with the approval of his Royal Highness the President, to Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S., in recognition of his important contributions, both theoretical and practical, to the developmment of the internal combustion engine, which in its latter forms has rendered aerial navigation possible, and is also extensively employed in the motor car, and in the submarine and for many other purposes.

DOMINIONS AND COLONIES SECTION.

FRIDAY, JUNE 9th, 1922; The Right Hon. Sir Frederick D. Lugard, G.C.M.G., C.B., D.S.O., in the chair.

A paper on "Tanganyika Territory (formerly German East Africa)" was read by Major Sir Humphrey Leggett, D.S.O., R.E.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, APRIL 28TH, 1922.

SIR WILLIAM GILLAN, K.C.S.I., LL.B., in the chair.

The paper read was :—

THE NEED FOR AN ALL-INDIA GAUGE POLICY.

BY FREDERICK GEORGE ROYAL-DAWSON, M.INST. C.E.

INTRODUCTION.

Ten years ago a paper on "Indian Railways" was read before this Society by the late Mr. Neville Priestley, a traffic officer who was at one time Secretary to the Indian Railway Board, and who subsequently became associated with the South Indian Railway, first as General Manager in India and finally as managing Director in London. Mr. Priestley's paper was taken up mainly with the financial side of the subject, the gauge question being only incidentally touched on as influenced by financial considerations in the past. Mr. Priestley's object was to show that an extensive programme of railway construction was needed, especially in the form of light feeder lines, to open out and develop the country, but that Government methods were not conducive to the encouragement of private enterprise in this direction. In particular, he sought to show that the high capital cost of some railways had been due to the Government's insistence on too high a standard of construction, and this gave rise to a question

being asked in Parliament. But on this point he laboured under a misapprehension, for in the first place, not being an engineer, he perhaps did not realise that the first cost of a railway was influenced more by the nature of the country passed through than by any arbitrary standard of equipment or strength, and in the second place, his assumption as to the insistence of unnecessarily high standards was not in accordance with the declared policy of the Government, for although certain standards had been laid down for important lines, the Government had specially emphasised that such standards could be relaxed in cases where they were considered needlessly onerous. I may add that this attitude of "Gharib Parwar" or "Protector of the Poor" on the part of the Government in relation to light railways still holds good, only such standards of construction being insisted on as are dictated by common sense.

The methods of Government in dealing with railways have, however, been exposed to criticism in other directions. For this reason a Commission was appointed the year before last, under the chairmanship of Sir William Acworth, to consider the whole question of the administration of Indian Railways, including the general question of railway finance, also the knotty question of State versus company management, and the adequacy or otherwise of the system of administration and control by the Railway Board as at present constituted. Their report was published last year. Although the gauge question was not specifically included within the scope of their investigations they recommended (with one dissentient) that this question should be referred to a Committee of experts. This report is now under consideration.

In the meantime the Institution of Civil Engineers kindly gave me an opportunity, for which I am much indebted to them, to present a paper on the subject of the Gauge Problem for discussion in that Institution last November. This paper was somewhat technical in detail, but the discussion which it elicited was most valuable in that it indicated that the majority of those who expressed their views and who were competent to form a disinterested opinion on the question, agreed generally with my conclusions. By means of the discussion, also, I was placed in possession of the strongest potential arguments that could be brought forward by opposing interests against my proposals and have thus had an opportunity to give these arguments full consideration when preparing the present paper. I am therefore in a position to assure this audience that the views whch I am about to express, although not official, are backed by a large body of disinterested opinion, that such adverse criticism as they have already received has been considered and dealt with in this paper, also that they are not novel in character, but merely that they have been brought up to date. I may also add that they do not conflict with any Government Policy, for the simple reason that the Government has no definite policy on the question at present.

Brief History.

It is necessary to begin the subject with a brief history of Indian Railways from the gauge point of view. Railway construction began in India about 70 years ago, that is in 1851, at a time when there were two legalised gauges on English railways, namely 7′ as used on the Great Western and the Railways which it absorbed, and the 4′ 8½″ as used on all other lines. A passing reference should be made to the "Battle of the Gauges" which had been fought in England a few years before, when other gauges had also been in use. The net result of that battle was the public recognition of the fact that the inherent merits of any particular guage were as nothing compared with the nuisance of a break of gauge, which prevented the rolling stock of one gauge being used on another. The first step towards the diminution of this nuisance was the legalising of the above-mentioned two gauges only, to the exclusion of all others. The second step came some years later when the Great Western, the sole representative of the 7′ gauge, decided to abolish it in favour of the more general 4′ 8½″ in the interests of unification, thereby serving its own as well as the public convenience. For some years before the final abolition of the 7′ gauge in 1892 the Great Western had adopted a mixed gauge on a portion of its main line, the track consisting of three rails, one rail being common to the two gauges. This was only the beginning of the end, for it was felt that the supposed advantages of a mixed gauge were not worth the complications involved in its maintenance as a permanent feature in dealing with a busy traffic. The use of the third rail,

however, showed that such a device could serve a useful purpose during the transition stage of a contemplated conversion.

America also had its "Battle of gauges," all lines being ultimately unified to the 4′ 8½″ or 4′ 9″ gauge in the interests of free interchange of traffic. This gauge has also become the main European Continental gauge.

With the above object lessons before them, the Government of India decided in 1851 that whatever gauge should be adopted in India, that gauge should be enforced for all railways, to avoid the evils of break of gauge. The actual gauge chosen as the legal standard was 5′ 6″, being intermediate between the two English gauges of that period. Incidentally it may be mentioned that this gauge was chosen to give, not greater capacity, but greater stability than the 4′ 8½″ gauge, as with carriage bodies of the same width there would be less lateral overhang in the rolling stock of the 5′ 6″ gauge.

Within the next fifteen or twenty years, about 5,000 miles of line, comprising the principal trunk routes leading from trade centres to ports, had been laid to this gauge by various companies with sterling capital on a 5% guarantee.

Unfortunately, these original lines were very costly in construction, not so much because the standard was unnecessarily high, but rather because the nature of the work was new, while the country was also difficult, involving the bridging of wide rivers and in some cases the traversing of steep mountainous tracts. Added to this initial handicap, the fall in the exchange value of the rupee resulted in these lines being a financial burden to the State. So that in 1869, when further railway extensions were desired for the development of the country, it was thought necessary to introduce a narrower gauge, namely the 3′ 3⅜″ or metre gauge, to be constructed by State agency in order to cheapen the first cost of construction. Thus for the first time were financial considerations allowed to interfere with the principle of uniformity, hitherto held to be of paramount importance.

An extensive programme was then carried out on the metre gauge. It is, however, due to the Government of that period to say that it was never intended that the metre should ever be anything but a supplementary gauge confined to particular areas. Mr. Thornton, in defending the Government policy at a discussion in the Institution of Civil Engineers, in 1873, said, "In India there was no idea of letting the two gauges come into competition. There were not to be any standard gauge lines and metre gauge lines running from the same point in the same direction. Goods brought by railway to any station at which the break of gauge occurred, and intended to go on by railway, would have no choice but Hobson's. They must either proceed by the metre gauge or by the standard gauge, as the case might be, or they could not go on by railway at all, for there would be but one gauge to go on by." It is thus evident that whether the introduction of the metre gauge was right or wrong in principle, it was fully intended to restrict the activities of that gauge to definite regions. To perceive to what extent that idea has been departed from, it is only necessary to glance at a present-day railway map of India (vide Fig. 1.)

While the broad gauge still predominates the metre gauge crosses it at many points. The original metre gauge State lines were the Indus Valley and Punjab Northern (since converted to 5′ 6″ and merged in the North-Western Railway), the Rajputana-Malwa, still on the metre gauge but worked by the Bombay-Baroda broad gauge administration, the Tirhoot (now worked by the Bengal and North-Western metre gauge railway, which came later), and the Northern Bengal now forming the metre gauge section of the Eastern Bengal Railway.

Later on came the Southern Mahratta Company's Railway on a guarantee, and the Bengal and North-Western without guarantee. The former is now incorporated in and worked by the nucleus of the old broad gauge Madras Railway, while the Bengal and North-Western, though financially independent, has, from an early period, benefited from the fact that the lucrative Tirhoot Railway has been leased to it. In the meantime the Assam-Bengal and Burma Railways on the metre gauge came into being.

In the South of India the portion of the South Indian Railway between Erode and Negapatam was originally broad gauge, but is now metre.

Up to this stage the metre gauge areas were fairly well defined, but as the trend of affairs seemed uncertain, the Government in 1889 invited a Committee of railway

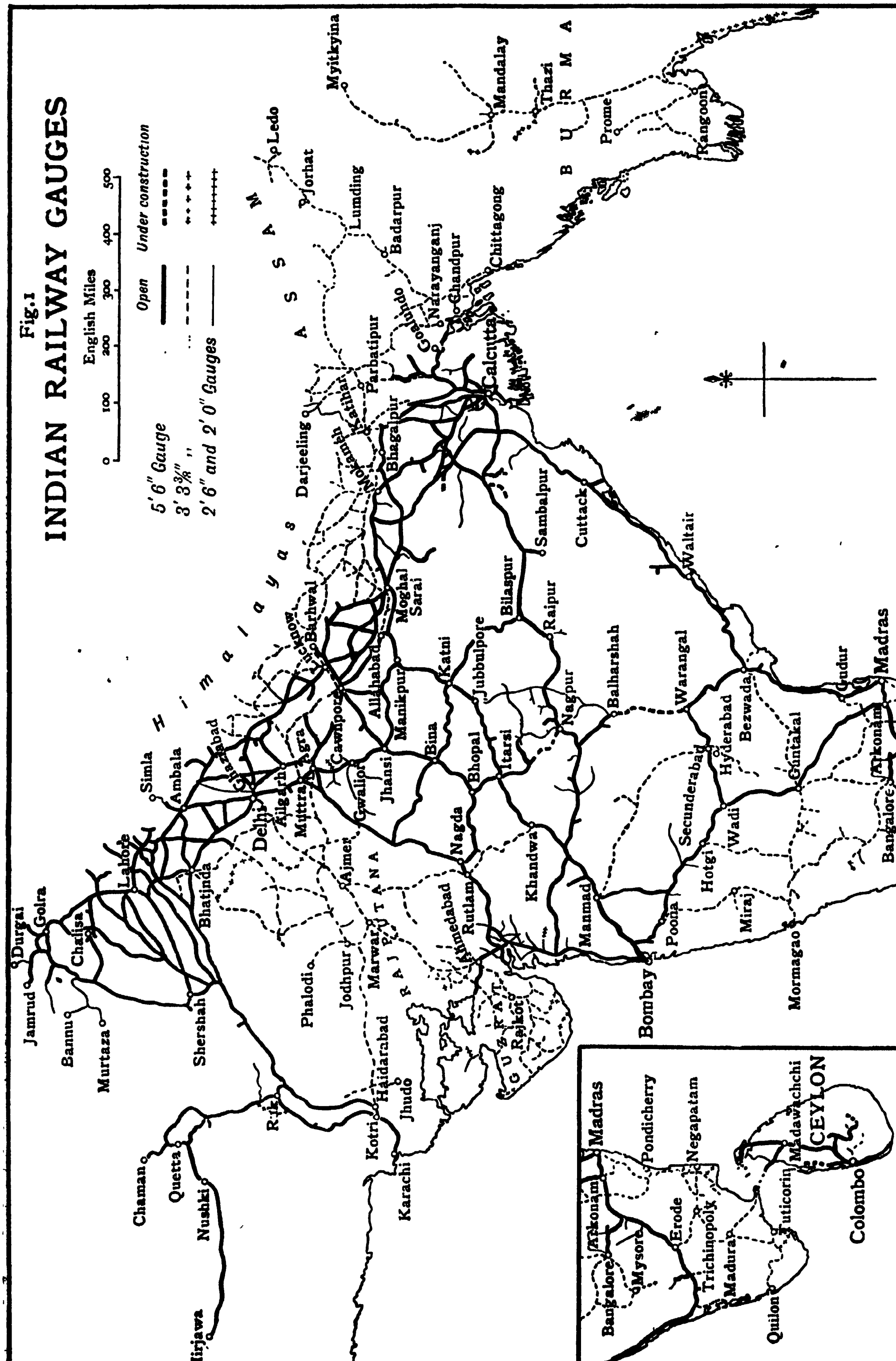


Fig. 1
INDIAN RAILWAY GAUGES
English Miles
0 100 200 300 400 500
Open
Under construction
5' 6" Gauge
3' 3⅜" "
2' 6" and 2' 0" Gauges
H i m a l a y a s
A S S A M
B U R M A
R A J P U T A N A
G U Z E R A T
Myitkyina
Mandalay
Thazi
Prome
Rangoon
Ledo
Jorhat
Lumding
Badarpur
Goalundo
Narayanganj
Chandpur
Chittagong
Calcutta
Parbatipur
Darjeeling
Katihar
Mokameh
Bhagalpur
Sambalpur
Cuttack
Waltair
Bilaspur
Raipur
Moghal Sarai
Barhwal
Lucknow
Allahabad
Manikpur
Katni
Jubbulpore
Nagpur
Balharshah
Warangal
Bezwada
Madras
Gudur
Arkonam
Guntakal
Hyderabad
Secunderabad
Wadi
Bangalore
Itarsi
Bhopal
Bina
Jhansi
Cawnpore
Gwalior
Agra
Muttra
Aligarh
Delhi
Saharanpur
Ambala
Simla
Lahore
Bhatinda
Ajmer
Nagda
Khandwa
Manmad
Hotgi
Miraj
Mormagao
Poona
Bombay
Rutlam
Ahmedabad
Rajkot
Marwar
Jodhpur
Phalodi
Haidarabad
Jhudo
Kotri
Karachi
Rohri
Shershah
Chalisa
Golra
Durgai
Jamrud
Bannu
Murtaza
Quetta
Chaman
Nushki
Mirjawa
Madras
Pondicherry
Negapatam
Arkonam
Erode
Mysore
Bangalore
Trichinopoly
Madura
Tuticorin
Quilon
Madawachchi
CEYLON
Colombo
Emery Walker Ltd. sc.

officers to enquire into the gauge question. This Committee recommended definite recognition of the 5′ 6″ gauge as the standard for India, and the rigid prohibition of any extension of the metre gauge, except in areas where it was already established. They further recommended that all feeder lines should be constructed on the same gauge as the parent line, but that anything of the nature of link connecting with broad gauge railways should be either constructed on the broad gauge, or so constructed as to be easily converted to it.

But these recommendations were not acted upon, for in the nineties the idea was started that all metre gauge railways should be connected with one another by metre gauge links. As a result of this heresy, the Cawnpore-Barhwal link, 80 miles long, was constructed by State agency across the broad gauge territory of the Oudh and Rohilkund Railway and actually alongside the broad gauge track of that railway between Cawnpore and Barhwal, to connect the Bengal and North-Western with the Rajputana-Malwa and Guzerat metre gauge systems, while with the idea of an ultimate north-and-south metre gauge connection, the Hyderabad-Godaveri line, 391 miles long, was constructed over hitherto unoccupied territory, on the metre gauge, although connecting only with broad gauge railways at its two extremities.

Thus the recommendations of 1889 have been scattered to the winds, and there is now considerable interlacing of the gauges. Although the Guzerat and Jodhpore-Bikaner railways connecting with the Rajputana-Malwa system appear to be at present in purely metre gauge territory, the Karachi-Agra broad gauge project, which is likely to materialise in the not very remote future, involves the conversion of the greater part of the Jodhpore-Bikaner main line to broad gauge, besides the crossing, if not the conversion, of a portion of the Rajputana-Malwa. Similarly the north and south backbone line of the metre gauge section of the Eastern Bengal Railway is in process of being converted to broad gauge. These contemplated conversions serve as illustrations of a generally accepted, though not officially recognised, principle that arterial routes should preferably be on the broad gauge, and that, as a corollary, if a metre or other narrow gauge line occupies an alignment approximating that required for a contemplated arterial route, it is, in the absence of specific legislation to the contrary, liable to be converted to broad gauge. As we have seen, some of the original metre gauge lines, such as the Indus Valley, being arterial in character, were subsequently converted to broad gauge.

A notable exception is the Rajputana-Malwa, which, before the construction of the Nagda-Muttra, was aligned on an arterial route between Delhi and Bombay, breaking gauge at Ahmedabad. It was at one time contemplated that this line would be ultimately converted, in anticipation of which it became the practice, when girders were due for renewal, to renew them up to broad guage standard. Then came the construction of the Nagda-Muttra broad gauge railway, on an alternative alignment, through much more difficult and less productive country. This line, it is true, takes a heavy through traffic, but there is no apparent reason why, if the Rajputana-Malwa had been converted to broad gauge, as originally contemplated, it could not have dealt with this through traffic as well as its own. Of course, it may be argued that the Nagda-Muttra has served to open up new country, but, taking a wide view, the anomaly remains that, as between the two alternative routes the more important and less difficult terrain of the Rajputana-Malwa is served by a metre gauge railway, while the less important and more difficult terrain of the Nagda-Muttra is served by the broad gauge. The acquired importance of the latter is derived mainly from its through traffic, which has been more or less diverted from the Rajputana-Malwa and the Great Indian Peninsula routes between Delhi and Bombay.

The true explanation of this retention of the Rajputana-Malwa as a metre gauge line is, perhaps, to be found in the Cawnpore-Barhwal metre gauge link, already referred to, traversing the broad gauge zone of the Oudh and Rohilkund Railway, and actually laid alongside a broad gauge track, to connect the Rajputana-Malwa and Bengal and North Western systems.

Thus, we see how one departure from principle has led to another. The first departure from principle was the introduction of the metre gauge, on the grounds of cheapness of first cost, to supplement the standard gauge, in spite of the break of gauge involved thereby. The next de-

parture from principle was to connect two metre gauge systems with one another by a link traversing broad gauge territory, in order to increase the lead of purely metre gauge traffic, in full recognition of the fact that such a link represented redundant mileage, besides failing to obviate the necessity of transhipment points with the broad gauge in other directions.

It has been argued in defence of this particular example that the link was necessary in the public interests in order to develop the trade between the Sub-Himalayan region represented by the Bengal and North Western Railway on the one hand, and the Rajputana and Guzerat areas on the other. While fully recognising the force of the contention, a counter argument would be that there is no *a priori* reason why, on public grounds, the Bengal and North Western Railway should be connected with the ports of Guzerat by an unbroken gauge, while it has to break gauge with the more important ports of Calcutta, Bombay and Karachi, involving transhipment at about a dozen different points. In short, weighing the arguments against one another, the suggestion arises that, on general grounds, links of this nature are more conducive to the interests of the linked railways than to public interests as a whole, in the sense that, while they may create new traffic, they also tend to influence the natural trend of traffic. It must also be obvious that, if this linking up policy were carried out indefinitely, it would mean redundant mileage and consequent waste of capital everywhere, while it would not save the general public from the evils of break of gauge until every station in India had been served by both gauges, which is a *reductio ad absurdum.* Short of that consummation, the aggregate tonnage of transhipment would increase concurrently with the co-extensive increase in the mileage of the two gauges.

To those who argue that the introduction of the metre gauge in the seventies was an economic necessity, in order to increase the railway mileage of India at a lower first cost than would have been possible by the use of the standard 5′ 6″ gauge, the reply is that an even greater mileage could have been secured for the same money by a yet narrower gauge, such as 2′ 6″. It is significant that the existence of the metre gauge has not prevented the subsequent genesis and growth of 2′ 6″ and 2′ 0″ gauges. To those who say that a narrower gauge would not have fulfilled the purpose for which the metre gauge was intended, the reply is that for thirty years after the metre gauge had been introduced, its average volume of traffic, measured by earnings in rupees per mile per week, had not attained the figures which several 2′ 6″ gauge lines can show at the present day. It should, however, be remarked that certain original metre gauge lines, such as the Indus Valley and Punjab Northern, were subsequently converted to broad gauge.

Assuming, however, that the metre gauge performed a useful function at a certain period in railway history, thus condoning the breach of the principle of uniformity for the time being, the fact remains that the metre gauge has grown to such an extent as to constitute at the present time a second main gauge. In other words, a dual gauge is now in full play. The present railway mileage according to gauges is, in round figures :—

Broad gauge	..	18,200 miles.
Metre gauge	..	15,300 ,,
Narrow gauges	..	3,500 ,,
Total ..	..	37,000 ,,

These figures represent route mileage only. For actual track mileage the figures for the broad gauge should be increased by about one-seventh to cover the double track portions on that gauge. With the exception of a small portion of the main line in Burma, and two short incidental "necks," seven and ten miles long respectively, in Upper India, the metre gauge is still practically all single track throughout India.

The outlay on the various gauges bears a close relation to their respective gross earnings, thereby indicating that the ultimate cost of a railway depends more on its volume of traffic than on its gauge. Thus, in 1883 the average cost per mile of a broad gauge line was 2.68 times that of the metre gauge, and the earnings 2.69 times as great. Again, in 1903, the average cost of the broad gauge was 2.49 times that of the metre, and the ratio of earnings also 2.49. Lastly, in 1920, the broad gauge cost per mile was 2.31 that of the metre gauge, and the ratio of earnings 2.35. It may be added that the average cost per mile of a narrow gauge line (2′ 6″

or 2′) in the same year was .57, or rather more than half that of the metre gauge, while the earnings per mile were .40, or rather less than half.

I leave the narrow gauges out of the discussion for the present, because in the first place their combined mileage is comparatively small, and in the second place they carry their own limitations in regard to capacity and speed, so that they can never attain the status of main lines.

The questions at issue are—

(1) is a perpetuation of the dual standard desirable in the public interests ?

(2) If not, is alleviation of the evil financially practicable ?

I propose to answer the first question in the negative and the second in the affirmative.

Evils of Break of Gauge.

I will deal first with the evils of break of gauge, which are the inevitable results of the dual system.

Formerly it was assumed that the inconvenience of a break of gauge was confined to the actual handling charges of transhipment, the amount being equivalent to a few miles (say, 10 or 20 miles) of extra haulage. We now know by bitter experience that that is the least important factor of the situation. The main evil lies in the serious detention to rolling stock at every point of transhipment, amounting to at least a day, and sometimes several days, for every train concerned. This means incalculable delays in transit and the corresponding waste of locked-up capital, not only in rolling stock, but also in the goods carried. A certain agent of the Eastern Bengal Railway, which has both gauges in its system, estimated that from a railway point of view alone it would pay to spend Rs. 20 lakhs of capital outlay (equivalent to, say, £133,000—but this figure does not pretend to be exact), to avoid the transhipment of one broad gauge train a day. Again, every transhipment point is a fruitful source of damage and loss by theft of goods in transit, especially at important junctions, where transhipment on a large scale takes place. The Indian public, who have been brought up to regard this state of affairs as inevitable, do not appear to realise what a difference uniformity of gauge would make in the efficiency of railway transport and the development of trade generally. The evils of a break of gauge cannot be exaggerated, for, with the co-expansion of the two gauges, they increase with the increase of tonnage transhipped.

As to whether wholesale transhipment at a big junction is preferable to transhipment at several scattered points for the same aggregate tonnage much depends on circumstances. In theory it may seem more convenient and economical to tranship 10,000 tons at one big junction instead of at a dozen scattered small ones. But in practice the worst congestions occur at big junctions, whereas if all main lines were of uniform gauge and the only transhipment points occurred at wayside stations where local feeder lines of a different gauge joined the main line, all transhipments would be of a local character and would be done by local station staffs, more or less under the observation of consignor or consignee, as the case might be, and, therefore, subject to less risk of mishandling or unaccountable delays or loss in transit. So far as the consignor or consignee is concerned, therefore, there is no doubt that the least objectionable position for a transhipment is near the beginning or end of a journey, as in the case of a wayside station, served by a local feeder line, the latter being merely a substitute for local road transport.

From the administrative point of view the supply and movement of wagons is the chief difficulty, especially as between two administrations where exact synchronisation of supply at transhipment points is almost impossible of attainment.

Even railways which have the two gauges under one administration (such as the Bombay-Baroda, the South Indian and the Eastern Bengal), and which should, therefore, be able to insure the co-operation of both gauges in the punctual and adequate supply of wagons at transhipment points, find this process a perpetual source of anxiety and liable to break-downs at critical moments. The following extract from a report by Mr. Waring, who was deputed by the Ceylon Government to report on Indian Railways in 1895, is sufficient to illustrate the position, Sabarmati being a goods transhipment yard near Ahmedabad on the Bombay-Baroda line :—

> "It has often been said that, with proper management, a block or serious delay of traffic at a transfer station should never occur. To this I have only to reply that at Sabarmati, the junction between the Rajputana-Malwa (metre

gauge) and the Bombay-Baroda and Central India (standard gauge) Railways which, it is to be noticed, are both under the same management, such blocks of traffic are, I understand, by no means unknown. The first result of such a block is that the sidings at the transfer station are choked with laden vehicles, the contents of which cannot be transhipped at sufficient speed ; all available sidings at the neighbouring stations then become similarly choked with vehicles, the goods stations throughout the line become choked with traffic, which cannot be despatched owing to the insufficient supply of wagons, and then the mischief extends in both directions, causing complete dislocation of all traffic arrangements, until by the most strenuous efforts the block of wagons at the transfer stations are removed. If this state of affairs can occur when the two railways are under the same management, it is evident that it is still more likely to happen when the lines are under different ownership."

Although the above report was written in 1895, it is equally applicable to railways in general at the present day. In fact, so far from showing an improvement, the present position has become worse with the general growth of traffic. The general public who become aware of a difficulty in supplying wagons, but who do not know the cause, assume that the railways are not sufficiently equipped with rolling stock, and set up a clamour for more wagons. Whereas it is evident from the above description that what is required is not necessarily more wagons but a greater synchronisation of movement between the two gauges, hardly attainable under the most careful management, and therefore irremediable under the dual gauge system.

It may be said that blocks occur even on railways of the same gauge. That is true, and the remedy for that is greater terminal and junction facilities. But while reforms are needed in this direction also, the railway system as a whole can never be made an efficient transportation machine so long as the greatest evil of all, namely, break of gauge, is tolerated.

Even if we look at the least important factor in transhipment, namely, the actual handling charges, equivalent to say 10 or 20 miles of extra haulage, at every transhipment station for every ton transhipped the question arises, why should trade be handicapped by such an extra charge *in perpetuo*, if a uniform gauge is a practicable proposition to any degree ?

The above considerations are, I hope, sufficient to furnish a reply to the first point at issue, namely, that the perpetuation of the dual gauge is *not* to the public interest.

THE GAUGE DILEMMA.

Before proceeding to the second point at issue, the difficulties of the situation must be considered. Unfortunately the gauge problem appears to have been studied hitherto almost entirely from a purely railway point of view. To a railway administration a break of gauge is a nuisance to the extent that, besides holding up wagons unnecessarily, it involves the perpetual task of arranging for the transfer of consignments from one gauge to another. But from a dividend point of view railways do not appear to suffer much by these inconveniences. So long as they can carry in their own time all traffic offering itself in the course of the year, without guarantees as to date of despatch or time of transit, their obligations to the public are, I believe, legally fulfilled and their earnings are more or less assured. It is probably for that reason, and in the absence of an enlightened public opinion, that railways have hitherto made no real attempt to initiate a unification scheme.

I do not make this suggestion in disparagement of railway administration, I merely put it as a possible psychological explanation of the existing state of affairs.

Possibly the reason that the recommendations of 1889 were never acted up to was because they did not carry sufficient conviction in the face of vested interests at that time, and possibly because there was no public opinion on the subject. Moreover, the subject was not so well understood then as it is now. In the circumstances it is not unnatural that the metre gauge, being the minor gauge, would strain every nerve to secure what it believed to be vital to its own interests, and the present day map shows that its achievements have been considerable and its potentialities very great. Its most noteworthy achievement, in the tactical sense, was perhaps the Cawnpore-Barhwal link, already referred to. The material success of this link from the metre gauge point of view

has rather tended to obscure its objections on more general grounds. It may be supposed that its inception was due to the theory that trade would be fostered between the metre gauge regions of the Bengal and North-Western and the Rajputana-Malwa by connecting them with a metre gauge link. This theory, confirmed by results, clearly demonstrates what a deterrent effect the previous break of gauge must have had on the flow of traffic interchanged between the two areas. Nowadays, however, defenders of the dual gauge are prone to argue that the evils of the break of gauge are insignificant. But we cannot have it both ways. If the latter hypothesis is true, then the Cawnpore-Barhwal link was an unnecessary expense. On the other hand, if the evils of break of gauge are admitted, then the true remedy would appear to be, not connecting links to maintain the minor gauge, but conversion of the minor to the standard gauge as traffic develops, in order to remove the need for transhipment. These are the sort of reflections that the existence of the Cawnpore-Barhwal link will always give rise to, unless the link is regarded merely as a temporary stop-gap, fulfilling a useful purpose at a certain stage of the evolution of railway traffic, pending final conversion.

Another example of the influence of gauge on the trend of traffic occurs in the case of the Fazilka-Kotkapura-Bhatinda branch of the Rajputana-Malwa metre gauge railway, which is worked by the Bombay-Baroda administration. This branch, about 77 miles long, of which Fazilka-Kotkapura is about 50 miles, was in existence before the broad gauge railways which immediately surround it were constructed. Consequently the traditional port for Fazilka traffic is Bombay, although the nearest port by rail has, for many years, been Karachi. The latest broad gauge line is that connecting with Fazilka on the west side, and it is significant that since the construction of this line the proportionate flow of traffic from the Fazilka-Kotkapura section for Karachi, as compared with that for Bombay, has been slowly but perceptibly increasing, in spite of the break of gauge at Fazilka. The inference is that traffic from this region would always have been for Karachi, in preference to Bombay, if it had not been for the metre gauge offering the least line of resistance for so many years. It would therefore be obviously to the public interest to convert this section to the broad guage, thereby, incidentally, saving the redundant Kotkapura-Bhatinda link, 27 miles long, which would go a long way towards paying for the conversion, even though the interests of the Bombay-Baroda administration might be slightly affected.

Suggested Remedial Measures.

I now proceed to formulate my proposed measures to alleviate the evils of the dual gauge. They are based on the natural growth of traffic on every railway. When the traffic begins to exceed the capacity of a single line, the railway is faced with the alternative of doubling or conversion to a wider guage. In the case of the metre gauge the cost of conversion to broad gauge is, generally speaking, rather less than that of doubling, while the immediate effect of conversion is to double the capacity of the track. The point to note is that all railways must incur additional capital expenditure from time to time to meet the natural growth of traffic, so that, if it became a recognised rule that the metre gauge railways, which, as already noted, are still practically all single track, should be converted to broad gauge in preference to doubling as soon as their traffic exceeded the capacity of a single track, the metre gauge would be automatically eliminated in course of time, practically without incurring any expenditure beyond that which would have to be incurred in any case to meet the growth of traffic. So much for existing metre gauge lines. An exception might be made in the case of Burma and the Assam-Bengal railway, which being more or less isolated from the general railway system of India, could be left out of the conversion scheme for an indefinite period without detriment to public interests. Other metre gauge areas would also be left undisturbed so long as the traffic was insufficient to justify conversion.

The construction of new lines on the metre gauge would have to be restricted by legislation in such a way as not to further prejudice the position.

To meet the objections of those who argue that the poorer and undeveloped districts of India would not yield sufficient traffic to make a new broad guage line pay its way, I propose that 2′ 6″ and 2′ feeder lines be permitted as at present, on the understanding that such lines be converted to broad gauge as soon as the growth

of traffic is sufficient to justify the cost of conversion.

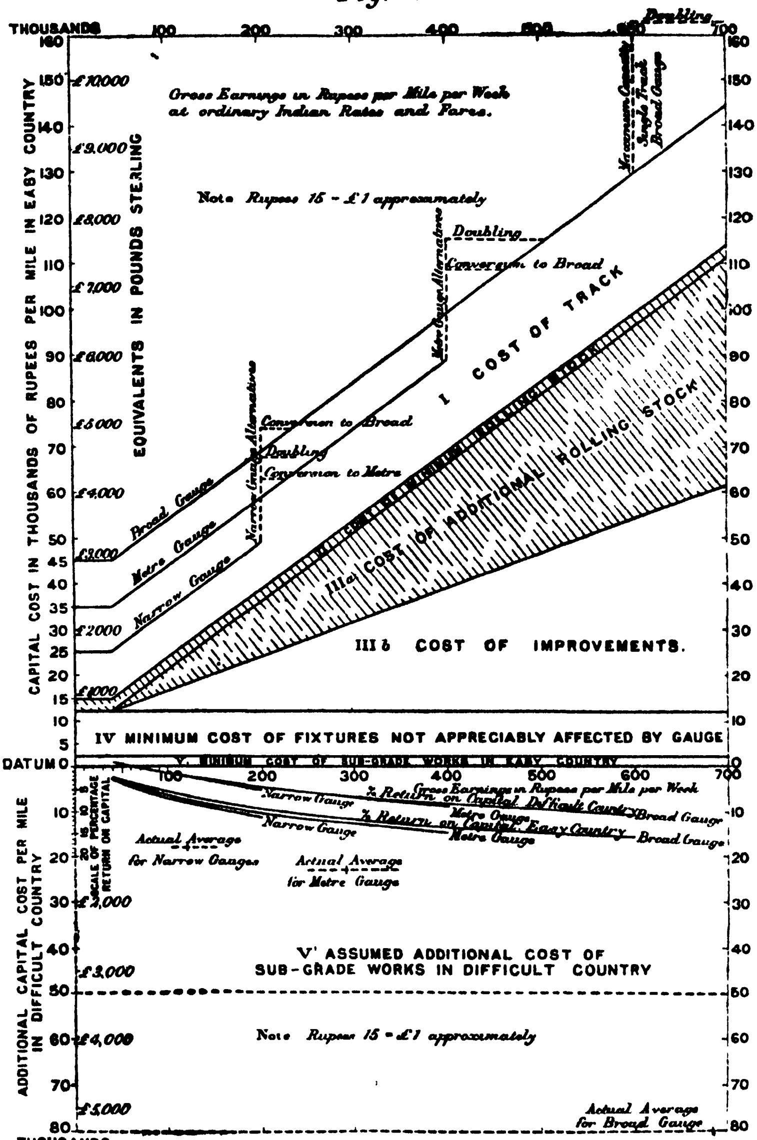
The above are the three salient features of a policy which, if carried out intelligently and consistently, would rid India, in course of time, of the curse of the dual gauge without involving more expenditure, practically, than that required to meet the natural growth of traffic.

In considering the practicability of carrying out such a policy, it should be noted that the principal railways of India are state-owned, of which three are also state-managed, the remainder being company worked on such terms that Government gets by far the greater share of the profits as the predominant partner. Moreover, the present time is specially favourable for considering the question, for the recent five years' programme, drawn up by the Railway Board, shows that all available money for the next five years will be required for the rehabilitation of existing lines, so that the construction of new lines will be practically suspended during that period.

Of course, it is to be expected that each feature of the proposed scheme would have its opponents. For instance, it has been urged that the conversion of the main line of the Bengal and North Western would involve the creation of about thirteen transhipment points at the junctions of its main line with branches, unless the latter were converted too. Against this may be set the fact that at least a dozen existing transhipment points with other railways would be wiped out automatically by such conversion, not to mention the credit obtained from the dismantling of the existing 80 mile Cawnpore-Barhwal link, which would by this scheme automatically cease to serve any purpose. As between the dozen or so local transhipment points which would be created by conversion and the existing dozen inter-railway junction transhipment points which are now necessary, there is no doubt that the public would prefer the former alternative if for no other reason than that such points would be nearer the consignor or consignee, as the case might be. Moreover, on general grounds, the aggregate tonnage which would be transhipped between branches and main lines would presumably be less than the aggregate tonnage of main line and branches combined to be transhipped to other railways and vice versa, so that such a move would be a distinct step towards mitigating the evils of break of gauge. As regards dividends, there is no reason whatever to suppose that dividends would be adversely affected by conversion, any more than they would by doubling. It is to be borne in mind that my proposals do not involve the conversion of a single metre gauge line before the traffic reaches the limit when the choice between doubling and conversion is forced on the railway. On the other hand, I do not believe that there is a single metre gauge railway that would not benefit by conversion when the time came. It is an established fact, though not sufficiently recognised, that the working of the metre gauge is inherently less economical than that of the broad gauge ; that is to say, for a given volume of traffic in a given tract of country, and under a given administration, the cost per ton-mile or per passenger-mile, would be less on a broad gauge railway than on an equivalent metre gauge line. As regards capital cost, we have already seen that the cost of a railway depends more on the volume of traffic than on the gauge. The only conditions under which the gauge is an appreciable factor of first cost is (1) when the traffic is very light, and (2) when the country is very easy, especially when the track is allowed to be laid on an existing public road. This is shown clearly in the diagram (Fig. 2). In such circumstances, a 2′ 6″ line would be obviously cheaper than a metre gauge at first cost, while it would be capable of meeting a growth of traffic by the provision of additional rolling stock and other facilities, from time to time, until the volume of traffic attained sufficient proportions to justify conversion to broad gauge. Thus the whole of the traffic of India could, in course of time, be worked by the broad gauge, supplemented by narrow gauge (2′ 6″ or 2′ 0″) feeder lines, so that the use of an intermediate gauge, such as the metre, would be superfluous.

Against the contention that capital cost depends more on volume of traffic than on the gauge, it is sometimes pointed out that the sharp curves which are possible with the narrow gauge as compared with the broad make a great difference in the cost of earthwork, as between the gauges in mountainous country. My reply is that such reasoning would apply only to certain mountain railways, which, being always of a special character, hardly come within the

Fig. 2.



CAPITAL COST PER MILE IN RELATION TO GROSS EARNINGS PER MILE PER WEEK TYPICAL DIAGRAM BASED ON ACTUALS.

scope of the gauge problem. The majority of narrow gauge lines are laid in very easy country, so that the sharpness of the curves used has no material effect on the cost, as compared with other factors.

As regards the proposed restrictions on the construction of new metre gauge lines by legislation, I believe legislation to be necessary as the only way to secure continuity of policy in the direction of unification, which is what is badly wanted.

To this end I proposed, in my paper to the Institution of Civil Engineers, that the Indian Railway Act be amended and enlarged so as to include a section dealing with the gauge question, the provisions of the section to be somewhat as follows :—

(1) This section of the Act shall apply to all parts of India, except Burma and Assam.

(2) The 5ft. 6in. gauge shall be the standard gauge.

(3) Any railways or portions of railways under the operation of this section of the Act not conforming with such standard gauge shall be converted to that gauge when, in the opinion of the Governor-General in Council, such conversion is required in the public interests.

(4) The construction of all new railways shall be on the standard gauge, except as may hereinafter be provided.

(5) Subject to the operation of Clause 3 :—

(A) Lines of light traffic, when cheapness of first cost is an important consideration, may be constructed on the 2′ 6″ gauge, or on the 2′ gauge in case of extension of existing 2′ lines.

(B) A new line may be constructed on the metre gauge only on the following conditions :—

(i) that it is an extension of an existing metre gauge line ;

(ii) that it does not connect with or cross over a standard gauge line.

N.B.—Under this sub-head, connection means the provision of direct tranship arrangements.

Before leaving the subject of legislation, I may recall the fact that the present uniformity of gauge in the United Kingdom is due to the timely legislation of the forties, and that the confusion of gauges which exists in Australia, South America and other countries, is due to the absence of such legislation in those countries.

It may be said that the above measures would not be sufficiently elastic, but I am of opinion that, taken as a whole, such a policy would be infinitely more satisfactory than the present opportunist formula of treating every case on its supposed merits, without reference to any recognised guiding policy, by which gauge questions are settled under present circumstances.

I will conclude by saying that I fully appreciate the merits of the metre gauge, but the point is that it is too good for a mere supplementary gauge. Its virtues are the strongest arguments against its retention. For as long as it exists it will strive to extend its activities in competitive areas, and thus aggravate the evils of the dual gauge to the hindrance of real progress in transport efficiency and commercial interests as a whole. If unchecked it will lead to an expensive struggle in which the broad gauge must ultimately prevail, because, as I pointed out in my paper to the Institution of Civil Engineers—

(a) The capital sunk in it is already more than double that of the metre gauge.

(b) It now carries 80% of the total railway tonnage of India at remunerative rates.

(c) It is inherently more economical in working than the metre gauge.

(d) It has higher potential speeds than the metre gauge.

(e) It is susceptible of indefinite expansion.

My proposed legislation, therefore, aims at attaining by peaceful and economical methods the ultimate removal of an incubus in railway transport in India, in the shape of the dual gauge, which it seems hardly fair, either on moral or economic grounds, to inflict on posterity.

[The Society is indebted to the Council of the Institution of Civil Engineers for the loan of Fig. 1 and for permission to reproduce Fig. 2 with certain alterations suggested in the discussion.]

DISCUSSION.

THE CHAIRMAN (Sir R. W. Gillan) said that personally he did not feel very competent to contribute to the discussion, especially in the presence of various eminent railway authorities, but he might make a few remarks, strictly as a layman. The first thing he would like to do was to draw a necessary distinction. India was a museum of railways. It contained everything, from the lordly 5ft. 6in. to the toy 2ft. That day he had heard that some authority in Bombay proposed to make a 4ft. 8½in., just in order, he supposed, to complete the collection. But these railways had in common nothing except their mere rails. A discrimination must be made between classes, and he thought the two main classes were these: (1) lines of long distance traffic or trunk communications, and (2) what might be called local lines, whether described as "feeders" or, as someone had called them, "railed roads." These two classes had to be kept very distinct, or mistakes would be made. For the local lines it might be advisable to aim at connected systems, or possibly at a network of light rails all over the country, but in any case continuity of gauge was not in their case a paramount consideration. In the case of main lines, or railways proper, many people thought that gauge was paramount, and it was perhaps at this point that the difficulties had originated over the gauge question. The

origin of the difficulties might, that is to say, lie in the fact that the metre gauge was a possible gauge for both sorts of railways. He would not describe it as falling between two chairs; rather it seemed to sit on both chairs, or perhaps one might say that it was difficult at times to be sure on which chair it was sitting, for it served both for main line communications and for feeder lines. To vary the metaphor, they might say that it made the best of both worlds, and he thought the issue before them was very much in this sense, that adherents of the metre gauge said that it was a universal gauge available for either class of railway, while the adherents of the broad gauge said that it was not the best for either. The two main questions as they appeared to the speaker were these. In the first place, was continuity of gauge a paramount consideration in the case of railways proper? Was it something to which they ought to subordinate other advantages, it might be to a considerable extent? Many of the arguments that had been brought forward in India seemed to indicate that it had this character, but in practice it had been treated as of comparatively little importance. Then, in the second place, the question was which was the preferable gauge for the main system of railways, assuming that there should be one? The arguments which had been advanced here, seemed to favour a broad gauge, but on behalf of the metre gauge it was answered that the metre gauge, at any rate, sufficed for the requirements of main line communications, and the question, therefore, transferred itself to this, whether the advantage of the broad gauge was of sufficient extent to counterbalance other considerations. He thought the views formed on these two questions would largely influence the decision taken on any particular project put forward, whether the construction of new lines or the provision of larger capacity on existing lines, but they would be complicated by other factors—in particular, traffic considerations which were of vital consequence to the metre gauge lines would often be found to have a far-reaching effect. Mr. Royal-Dawson had said that in the long run the broad gauge was bound to predominate. He thought there were two facts which went against that conclusion. The first was that the metre gauge systems, unlike Government, had a perfectly definite policy, and the second was that, also unlike Government, they were always prepared to finance what they considered desirable. The outlook generally, therefore, for this gauge question seemed to be as uncertain and as unsatisfactory as its past history had been. He thought that something ought to be done. Mr. Royal-Dawson had proposed legislation, and the speaker quite understood the considerations that had led him to that recommendation. But he was not sure that in the case of the Government of India legislation would be appropriate, seeing that they would be laying down rules, not so much for private companies as for themselves, and in any case he would say that it was clear that in spite of all the time and discussion given to this subject, it was not yet ripe for legislation. He would turn, therefore, to the report of Sir William Acworth's Committee on this subject, which said:—"Thorough investigation of the gauge problem is urgent at this moment. We think that the situation as it at present exists, must be faced as a problem affecting the whole of India, and examined from the engineering, operating, and financial side by a special commission of two or three of the first experts who can be found after careful search not in one country only." A commission of this kind would be able to lay down an authoritative policy which the Government would be able to carry out. If he (the speaker) were on the Railway Board still, he would welcome the assistance given by a body such as was proposed by Sir William Acworth's Committee in almost every project that came before the Board.

Lord Montagu of Beaulieu, K.C.I.E., C.S.I., said he had recently returned from India, where he had been studying railway systems and railway questions in general, including this very gauge question, and he must confess that, after considering the subject generally, his conclusions were more in accord with Sir Robert Gillan than with the reader of the paper. He was inclined to take this view, not only on account of what he considered its inherent soundness, but from the point of view of finance, which in these days was the most important consideration in railway construction in India. India proposed to borrow a large sum, to be spread over the next five years, for the rehabilitation of the railways, which at the present moment could not be described as being in anything like a fit state, either to carry the existing traffic or, still less, the traffic of the future. Therefore, the problem resolved itself into this: having raised the sum in question, how could the money best be spent? He did not think that an impartial judge would advocate that any considerable proportion of it should be spent on making the gauges more uniform. What Sir Robert Gillan had said was perfectly true. The traffic in bulk from ports was distributed up country in the main and at present moment by the standard gauge. The standard gauge went to every main port in India. It carried something like 80 per cent. of the traffic. The lesser gauges distributed and collected that traffic more or less in a radial fashion, and at various stations all over India on these narrow gauges, he was struck by the very small amount of traffic which did pass over these narrow gauge lines. He spent one day examining a local line which ran eighty miles west from Cawnpore, with a view to suggesting the running of rail motor cars, and he was impressed there with the very

small amount of traffic. He was told afterwards, that it was affected somewhat by strikes that were going on to the eastward, but even so, there was no doubt that that line was not employed to anything like its full capacity, and there was room for a good deal more traffic to pass over it. When one came to the construction of new lines, he would rather see a road as a feeder to a railway than the construction of more small gauges; and the modern use of motor vehicles with the less handling which they entailed at the points of origin and destination was really an argument for a diminished construction of feeder lines, and a greater construction of roads to feed the main line station. With regard to other points in the paper, he would ask the reader to consider whether the analogy of France was not worth studying. In France, the main lines of railway had a 4′ 8½″ gauge, which was the standard continental gauge, but there were also very successful light railways in the north of France for agricultural purposes, in the east for minerals, and in the south for passengers and goods. To take one railway which ran on the Riviera, from St. Raphael to Toulon, it would have been impossible to have got a standard gauge with all the necessary paraphernalia of stations, signals, and so forth on this line, but although it was worked in a casual way, it was worked quite cheaply and efficiently. It was really a "railed road." The French students of railway matters had always told him that they regarded these lines purely as feeders, rather than railways proper. To attempt to reconstruct the metre-gauge railways of India would entail a very large sum of money, and to attempt to do it when there were so many other urgent things to do, such as the provision of heavier locomotives and other important matters, would be a waste of money. He thoroughly agreed with the reader of the paper in some of his statements. There was no doubt whatever that the break of gauge at some of these points was a very serious matter to the public, even more than to the railway companies. It did not necessarily affect dividend-earning capacity, but the delay in some cases prohibited perishable traffic, and in these days, when the Indian coolie was not as tractable as he used to be, and his labour was very much more expensive, the handling and transhipment of goods at these interchange points was a bigger problem than in the past. As a remedy, it might be possible to use road wagons on crocodile trucks, or trucks with very low platforms, and tranship them from one truck to the other on the railway. This was done now on the London and South-Western, and also on the Continent. Then, again, there was the use of transporters at stations. In fact, he did not admit that all the means of interchange of traffic had been exhausted. Of course, there was no doubt whatever that, as the reader of the paper put it so well, given a certain tonnage from a certain distance and a certain number of passengers, they were conveyed more economically on a 5′ 6″ gauge than on smaller gauges. They must all deplore the fact that the gauges were made originally of such a diverse character, and he could only hope that, chiefly on the grounds of relative urgency, none of the borrowing for the railways of India would be spent on the alteration of gauges. But he admitted to the full that at some time in the future this gauge question would have to be considered.

Sir William M. Acworth, was quite sure that they would all be grateful to Mr. Royal-Dawson for his valuable paper. In one particular the best was the enemy of the good, and that was his map, in which he had tried to show too much. If his map had merely shown the metre gauge and the 5ft. 6in. gauge, it would have brought out what he had described so well in his paper—the way in which blocks of metre gauge were intersected by and cut across by lines of the other gauge, and so would have demonstrated what an unsatisfactory position had been reached. He hoped that the map might be simplified and re-drawn when the paper was published. He (the speaker) was not an engineer, and he wanted to confine his attention to the subject of the paper as headed, which was not "The Proper Gauge Policy," but "The Need for a Policy." If the map he had asked for were in existence it would be enough to hold it up in demonstration of that need. If his recollection was correct, the Indian railways began about 1851-1855. He was rather surprised that the big English engineers as early as 1855 did not see that 5ft. 6in. was not right to start with. By that time he would have thought they would have understood that 4ft. 8½in. was good enough. He wanted to put himself in the position of the man who first started the narrow gauge. He was quite sure that that man said that the people who started the 5ft. 6in. were wrong. He must have had that in his mind, and have decided that, because they were wrong, he was going to do something else. To-day he did not think anybody would deny that the people who had produced this crisscross system were wrong. The question was, however, ought we, in 1922, to have a policy? Mr. Royal-Dawson and Lord Montagu had spoken of the large sums invested. But we were only at the beginning of expenditure on Indian railways. The whole capital investment so far was only £400 millions, one-third of the capital invested in the railways of Great Britain. There were fewer miles of railway in India, for a population of 300 odd millions, than in Canada for a population of eight millions. India was only beginning to make its railways. It had got to make a vast number more. Surely it was necessary to have a policy before they went any further. His esteemed colleague,

Sir Henry Burt, had said, "For heaven's sake, don't start out to get a policy. It will be made the excuse for the Finance Department to refuse every penny of money to go on with, on the ground that the policy is not yet forthcoming." The speaker believed that it was desirable to get a policy before building any new lines, but the amount of which Lord Montagu had spoken as about to be borrowed by the Government of India was pledged for improvements of the existing system. After these improvements had been effected, they might begin to talk about extensions, and then would be the time to get a policy. He did not think people had appreciated the absolute non-necessity for the 5ft. 6in. gauge. Before he went to India he travelled a good many thousands of miles on the South African 3ft. 6in gauge, which was not very much better than 3ft. 3in. He travelled in perfect comfort, with sleepers and diners and so on, and on that gauge in South Africa they ran trains as heavy as the heaviest train he could find in India. The heavy trains in India from the coal-fields down to Calcutta were no heavier than those run in the Transvaal on 3ft. 6in. On the other hand, take the 4ft. 8½in., it was going to be a long while before anybody proposed to take a train heavier than, say, 17,000 tons—a load that has actually been hauled by one engine in America—over these lines, so that it seemed to him that the thing was open for discussion, and it had to be discussed from the point of view, not of what was done on the 5ft. 6in. or on the 3ft. 3in., but of what might be done. With what Mr. Royal-Dawson said about transfers he was absolutely in agreement. Nearly all the witnesses before his Committee said that they were short of trucks. They were not short of trucks a bit, there were plenty of trucks to move the traffic if they could only move the trucks You must tie up trucks and tie up roads when you come to tranship on a large scale. Why did the little original short-line railways in America and England come together in big systems? It was because they had not discovered in those days that it was possible to book traffic from one company to another on a clearing-house system. It was equally impossible to conduct a large traffic satisfactorily if there was unloading from one gauge to another. In theory they might be told that it was possible to take stuff out of one truck and put it into another in a certain number of hours or minutes at a certain number of pence or annas per ton. But that did not happen in practice, and never had done, and never would. That was the evidence all over the world. They always suffered from this break of continuity. It was worth almost anything to a railway man to get the power of working through. The best proof of it was that the Indian Government was putting up a broad-gauge line through the Khyber Pass. They knew perfectly well that they must not have a break at Peshawar, or they would have congestion there if they did. In the event of a sudden breakdown or sudden glut of traffic the break of gauge was of vital importance. Frankly, he did not see why legislation was required. What was required was a policy, and if such a policy were established and the Government strong enough to carry it out, it would pay the Government over and over again to be very generous in the case of a light railway that lost its traffic. It was a policy which was wanted, and not legislation. To the speaker this was King Charles's head. Why was there not a policy? Because India would not allow railway men to manage railway business. Why was a narrow-gauge railway made here and a narrow gauge railway there? Because the Finance Department said that it would cost an extra two lakhs or three lakhs, and that they had to balance the Budget. As long as that attitude was accepted he saw no hope for a policy. The essence of the question was that this was a matter which railway men understood and ought to understand: it was not a matter which financial people understood, and the railway men must be trusted to do it. If the matter were put to the Railway Board and they were told to present a policy, which it was their business to find, he was sure that they would go further and say that India was *qua* railways a single entity. It did not connect with railways anywhere else in the world. On the other hand uninterrupted communication throughout India itself was vital. The men who came home from India came home usually to England, probably the country least desirable from this point of view, to have its railways studied. He was sure that the Railway Board could profit by the experience of the people of Australia, who were face to face with the same problem. He had not seen the report made on the complicated problem of the gauge in Australia. But he was certain that in the long run—and not the very long run—it would pay abundantly to have a policy, and that policy ought to be threshed out on the understanding that it was to be a permanent and continuous policy and not interrupted by financial opportunism which had been mainly responsible for the confusion. If Mr. Royal-Dawson could revise his map it would do more for the cause he had at heart even than his very interesting paper.

Sir Charles H. Armstrong said that like the Chairman he could only deal with the matter as a layman. He was not a railway engineer nor a traffic or transportation expert. But he had some knowledge of the administrative work of a railway in India, and also of the commercial and industrial needs of India in general, and he thought this a very important factor in the question under discussion. They had been told that in 1851 the 5ft. 6in. gauge was decided upon as the standard gauge for India.

The first railway to be opened was in 1853. It was a short length of 21 miles from Bombay to Thana. In 1869, owing to financial reasons, it was decided to inaugurate the metre gauge system. In 1889 the broad gauge was again in the ascendant; a few years later it was decided to link up the different sections of the metre gauge, and he could not help thinking that if a decision was to be come to such as Mr. Royal-Dawson suggested, and a definite policy was laid down by an amendment of the Act—though he agreed that an amendment of the Act was not necessary, because the railway policy of India was entirely under the control of the Government of India—a few years hence, owing to financial or other reasons it might be found that a mistake had been made. At the beginning of his remarks Mr. Royal-Dawson referred to the paper read by the late Mr. Neville Priestley, and said that because Mr. Priestley was not an engineer he failed to grasp some factors which bore upon the first cost of construction of a broad-gauge line. The speaker had not read Mr. Priestley's paper, but he had no doubt that Mr. Priestley wrote it from the traffic point of view, because he was a traffic expert of great experience and a man of very far-seeing views. There could be no doubt that the great need of India at the present time, especially from the commercial point of view, was a great extension of her railway system. He remembered petitions, perhaps forty years ago, being sent to the Secretary of State by Chambers of Commerce in the North of England, particularly Manchester, urging the need of a much more rapid extension of the Indian railway system. If the need was urgent forty years ago, it was very much more urgent to-day. After seventy years there were only 37,000 miles of railway in India. Nothing was done in the way of extension during the War, and so far as he could see from the railway programme nothing was likely to be done in the next few years. The result would be that in very nearly eighty years the annual rate of progression would only have been 500 miles. This was very slow progress indeed. The financial question had dominated the position for a long time, and so far as he could see it was likely to continue to do so for many years to come, unless—he feared it was a vain hope—the people of India could be induced to put their money into the extension of their own railways, as the British public did many years ago. One had only to judge from the evidence lately given in India before the Royal Commission. The one cry was State management, control, and finance, which meant that the Government of India were to borrow the money wherever they could at a fixed rate of interest, and their power to borrow was, of course, limited. He was surprised by the recommendation in the paper that when a metre gauge line had reached its capacity it should be converted to a broad gauge rather than that it should be doubled on the metre gauge. He could not but think that traffic could be passed along a double line very much faster than along a single, and if that was so he felt that it would be a mistake to follow the plan which Mr. Royal-Dawson had suggested. There was another remark in the paper which also rather surprised him. It was said that if the railways of India could carry in their own time, without any guarantee as to date of dispatch or length of time taken in transit all the cargo offered to them, they had fulfilled their obligations to the public and had earned their dividends for their shareholders. He did not think that the railways of India regarded the movement of traffic from this point of view. There could be no doubt whatever that the future prosperity and wealth of India depended upon a great increase of her internal and external trade, though he was bound to admit that one would not imagine this point was realised from much of the evidence given lately before the Fiscal Commission. If the merchants of India could only get raw materials brought down to the coast in half the time it took to-day the external trade of India would be very greatly increased. What, of course, was needed in India was more and more railways. There were only 18,000 miles of broad gauge, and very nearly 19,000 miles of metre gauge and narrow gauge. He did not himself see how, having gone so far, they could go back, and he thought they would have to continue as they were, each project as it came forward being considered strictly on its merits. He had no doubt that, if it was dealt with in this way, every point Mr. Royal-Dawson had urged that afternoon would be carefully considered, but it would be a mistake to say that the policy in future should be only 5ft. 6in. gauge. There were many tracts in India which required opening up, where a 5ft. 6in. gauge would never pay, whereas a metre gauge might pay. He hoped that in future the extension of Indian railways would be very much more rapid than in the past.

SIR THOMAS H. HOLLAND, K.C.S.I., F.R.S., said that Mr. Royal-Dawson, referring to the damage done to goods by delays, had stated that the Indian public, who had been brought to regard this state of affairs as inevitable, did not appear to realise what a difference uniformity of gauge would make. The public of India had been shouting so much for the last generation for more waggons that they had become too hoarse to voice their views with regard to the cause of the shortage. The public, after all, was not in a position to analyse the causes for the grievances from which they suffered. The troubles that arose from a break of gauge did not affect to the same extent the portion of the public that was able effectually to make its voice heard through the Chambers of Commerce. With the single exception of the Upper India Chamber at Cawnpore, most

of the important Chambers were interested in the external trade of India, which was brought to and distributed from the ports. They were not, therefore, as merchants, interested in the change of gauge. The shipping firms at the ports very rarely saw any of these inconveniences which affect the up country small merchant and the inland industrialist. The whole railway atmosphere of India had acquired a psychological bias in favour of external trade. Vested interests had grown up and become firmly rooted with the help of this fertiliser. He would not say that the policy was wrong. Its effect had been distinctly to the general good of India, and those who would have to handle the new and very dangerous weapon of fiscal independence, would be wise to go very delicately indeed in the matter of external trade. The uncertainties of delivery were among the most serious of the grievances of the inland industrialist to-day. It must not be imagined for a moment that these were all due to the break of gauge. One knew quite well that delays occurred also on main lines. But they were paralysing the trade. They were paralysing the trader who had to think financially ahead, with the necessity of keeping an exact timetable, and meeting his payments from his receipts. But the practical problem, it seemed to him, had been rather overlooked in that discussion. The problem of immediate importance was not to settle whether the broad gauge or the metre gauge was the better, not even to decide whether the dual gauge was good or bad; the problem was to find out when and how the change could be effected. There was more than this. The problem was to convince those who had the power of sanction and those who had the power to act, and these in his experience were not likely to be moved by any kind of arguments or facts that were not reinforced by an authoritative and impartial committee After all, there were vested interests to be disturbed, and those who were hurt most would certainly make most noise. Sir William Acworth's Committee recommended that whilst the gauge question was really urgent it should be separately examined from the engineering, operative, and financial points of view by a special Commission. The Acworth Committee would not even suggest a solution themselves. There were points in the paper read by Mr. Royal-Dawson which would be likely to send the criticism in the wrong direction, among them the point referred to by Sir Charles Armstrong. "All railways" (said Mr. Royal-Dawson) "must incur additional capital expenditure from time to time to meet the natural growth of traffic, so that, if it became a recognised rule that the metre gauge railways, which, as already noted, are still practically all single track, should be converted to broad gauge in preference to doubling as soon as their traffic exceeded the capacity of a single track, the metre gauge would be automatically eliminated in course of time, practically without incurring any expenditure beyond that which would have to be incurred in any case to meet the growth of traffic." He (Sir Thomas Holland) took it for granted that any increase in traffic sufficient to call for the doubling of the track would occur on certain sections first and not on the whole line. Doubling one section would be possible and obviously advantageous, but conversion of one section to another gauge would merely add to the embarrassment. The conversion to broad gauge in preference to doubling as soon as the traffic exceeded the capacity of a single track, was not likely to appeal to the administration of any of the lines concerned. Reform would not arise spontaneously. Reform would not be effected except by force, and force would not be justified until it was shown by a judicial and impartial commission that conversion was really necessary in the public interest. It was no use arguing in that room that it was desirable They had to show how reform could be made. Railway administrators were not obstinately opposed to conversion. They knew that there were other ways of employing their capital, and that the difficulties in the way were expensive. Take the Committee's report of 1889. They laid down a rule that when links were to be constructed connecting metre gauge with broad gauge systems they should be either constructed on the broad gauge or should be so constructed as to be easily converted to the broad gauge. He quoted instances to show that that rule had not been observed faithfully. The present metre gauge administrations were likely to give more satisfaction out of working things as they found them than by criticising their predecessors and talking about policy. They must carry on as they found things. A simple unmodified law might not be practicable under present conditions, but still much might be done by way of conversion. There was the question of settling some order of precedence in the operations necessary even if conversion were accepted as advantageous generally. There might for example be certain areas on the peninsular section of India which were sufficiently self-contained to be left alone for the time being, like Assam and Burma. He was not inclined to follow Mr. Royal-Dawson in what he had said about stirring up public opinion He did not see how public clamour would help either the Railway Board or railway administrations. The members of the public were in no position to examine this question critically. It was not a simple question of metre gauge versus standard gauge, but a matter of discrimination locally as to where conversion was practicable and where it was desirable after the conflicting interests had been carefully balanced. They had to determine a programme by which the Government could act. It could not be done wholesale, it would not be done in a day, and any attempt to propose that would merely result

in nothing being done at all. The best line to follow now, therefore, was to support the Acworth recommendation for a special expert examination of the whole question.

MR. FRANCIS J. WARING, C.M.G., M.INST.C.E., thought there was no doubt whatever that the need for a railway policy in India was essential, but he could not agree with Mr. Royal-Dawson in his advocacy of the construction of 2′ and 2′ 6″ gauge lines to be converted when required into 5′ 6″ gauge lines. What he proposed was put forward as an alleviation of the present state of affairs, but to the speaker it appeared to be merely an aggravation of the evil which he so strongly deprecated, for Mr. Royal-Dawson was as fully aware of the folly of a break of gauge and the loss it entailed as anyone. Therefore it was surprising to him that he should advocate the multiplication of breaks of gauges all over the country. (Mr. Waring was not now speaking as an advocate generally of one gauge more than another; he was merely mentioning what he could not help believing would be an aggravation of the present evil.) Mr. Royal-Dawson talked of the conversion of the 2′ 6″ gauge into 5′ 6″; such a conversion would cost a great deal more than the conversion of the metre gauge line into the 5′ 6″ line, and as the Government of India had prescribed limiting curves of different gradient for lines of different gauges, the conversion of this very narrow gauge would often be almost tantamount to building a new railway altogether. It was a fallacy for railway engineers nowadays to talk of sharp curves being incompatible with a 5′ 6″ gauge. The introduction of the metre gauge into India was a mistake, and the really economical measure in 1869 or 1870 would have been the construction of light standard gauge railways. He was not defending the standard gauge of 5′ 6″ *per se*, but what he had always objected to was the break of gauge, and having that gauge which was still predominating he considered it should be adhered to. Railways having a gauge of 5′ 6″ had been built in Ceylon for £3,617 per mile, in New South Wales for £3,303 per mile, and in Victoria for from £2,000 to £3,000. There were certain branches of the Indian Midland which cost between 58,000 and 67,000 rupees per mile. In these heavy rails were laid. If lighter rails had been used a very appreciable economy would have been effected, because as a rule, in most ordinary railways in India and Ceylon, the cost of the permanent way was the greatest separate item in the cost of construction.

SIR THOMAS BENNETT, C.I.E., M.P., said that he must resist the temptation to embark upon the subject of Mr. Royal-Dawson's paper, though he would have greatly liked to have taken up some of the points. But he wanted to say something about the paper and the reader of it. The paper was admirable. It more than came up to the standard—a very high one—of the papers read before the Royal Society of Arts in the Indian Section. Mr. Royal-Dawson had done a service to India, for any contribution to the discussion of railway matters in India at this moment and in England would do good. They wanted to interest the public in England, and above all in the city, in every aspect of the railway question in India. Mr. Royal-Dawson, therefore, had done great service in laying such an admirable paper before them, and he was sure they would accord a vote of thanks to him for the labour and skill with which he had dealt with the question.

SIR LIONEL JACOB, K.C.S.I., seconded the vote of thanks, which was carried unanimously.

MR. ROYAL-DAWSON acknowledged the vote of thanks, and said that on account of the lateness of the hour it would not be possible for him to reply in detail to the discussion. It had been a great satisfaction to have elicited so many comments and criticisms, and there were a number of points on which he would like to make a reply, but he would send his reply in writing for publication in the *Journal*.

MR. SIDNEY PRESTON, C.I.E., C.B.E., writes:— If there had been an opportunity for me to speak at Mr. Royal-Dawson's paper, I had intended to emphasise more fully than Mr. Waring did in the limited time at his disposal the absurdity of trying to do away with the metre gauges while a third gauge—2′ 6″—is being deliberately introduced. I ventured to comment upon this point in the discussion on the late Sir F. Upcott's paper at the Institution of Civil Engineers in 1906. At that time I think the length of these little gauges amounted to about 1,100 miles; these now total 3,500 miles, and are therefore showing considerable expansion when it is remembered that there has probably been little or no new construction in the last eight years.

In my remarks referred to above I particularly drew attention to the line then under construction, or just completed, from Saharanpur to Ghaziabad. This line traverses probably one of the richest agricultural tracts in the country, being all watered by the Eastern Jumna Canal. It connects two standard gauge lines, so that anything arriving at either end for forward dispatch must be transhipped. How Mr. Royal-Dawson, after detailing the evil and delay of transhipment, can contemplate an extension of their narrow gauge I am unable to understand. It seems to me that the introduction of the 2′ 6″ gauge is simply making confusion worse confounded.

I believe that the official justification for their third gauge is that the 2′ 6″ lines are "tramways" made under the Indian Tramways Act and

are not "railways" under the Indian Railway Act. This may be the reason, but it seems to me it is a distinction without a difference; to all interests and purposes these 2′ 6″ tramways are railways, and as sanction to them can be given by the Local Governments, instead of requiring the sanction of the Government of India, as in the case of railways, there is likely to be a considerable increase in the mileage when money for construction is available.

I venture to think that the question of the 2′ 6″ gauge deserved more consideration than was given to it by the author. The Chairman referred to the "museum" of gauges in India from 2′ 0″ to 5′ 6″ He might have said from 1′ 6″ to 5′ 6″, as there is a considerable length of 18″ gauge in Gwalior State.

MR. S. M. RYAN, F.L.S., late India Forest Department, writes:—The solution of the problem of the battle of the gauges in India and Burma seems to lie in the direction of adopting Mr. Royal-Dawson's suggestion of the gradual conversion of all existing narrow gauge systems into a standard gauge and the introduction of road motor transport as feeders to all the railway lines.

The practical application of this policy would of course be contingent on adequate and cheap power being available for the efficient carrying out of road transport operations. Apart, however, from petrol, it has all along been believed that power from indigenous material was not at hand in either India or Burma for such a purpose, but this it is felt is a mistaken idea.

A proposal is in the course of submission to the Government of Bombay, at any rate, to show where and from what substances it can be produced in that Presidency, and that it only needs organisation and the expenditure of comparatively little capital outlay to enable such power to be made available.

If successful for the G.I.P. and B.B. and C.I. and Southern Mahratta lines, the scheme could be introduced in the Central Provinces, Bengal and elsewhere.

Just as water forms the basis of raw material for the execution of hydro-electrical schemes so large reservoirs of energy lie dormant in the forests of India which can be tapped with the aid of a little foresight and comparatively small capital outlay, and without disturbing the existing demands on them.

As three crores are to be spent on the improvement of the existing railways in India during the next five years (there is to be *no extension* of such lines, in this period, be it remembered), a few lakhs out of this might reasonably be earmarked for the development and extension of road motor transport operations if such can be demonstrated to be a practical proposition.

MR. ROYAL-DAWSON writes:—

I have to thank all the speakers for their interesting contributions to the discussion.

Sir Robert Gillan's division of railways into two distinct classes, namely, main lines and feeder lines, bears out the trend of my arguments. As he shows, the gauge question owes its complications to the fact that the metre gauge has been made to serve both functions concurrently with the existence of broad and narrow gauge lines which fall naturally into those two divisions. As the metre gauge has become a main gauge, the point at issue is whether there is room in India, any more than in any other country, for two main gauges. I fully agree with Sir Robert that the question cannot be settled authoritatively except by a specially appointed Committee of experts, as recommended by Sir William Acworth's Commission, and I should be glad to see the formation of such a Committee.

Lord Montagu of Beaulieu suggests that, as all available money for railways will be needed for the rehabilitation of existing lines for some years, there will be nothing available for conversion But this is not quite my point, which is that the question of conversion need not arise until a metre gauge line is compelled by traffic considerations to choose between doubling and conversion. There are several sections of metre gauge railway now confronted with that alternative. Hence the urgency of establishing a definite policy at the present juncture. On the other hand, Lord Montagu's reference to the lightness of existing traffic on some of the lesser gauges, with special reference to a local metre gauge line near Cawnpore, confirms my contention that the metre gauge is unnecessarily capacious for lines of really light feeder traffic. His advocacy of the use of feeder roads for road transport in preference to light railways is well worth consideration, in view of modern developments in road transport. Speaking of the two gauges in France, it is interesting to note that the narrow gauge railways in that country are confined to light and local functions, so that no gauge complications can arise in long distance traffic on main lines, which are all of uniform 4′ 8½″ gauge. It is satisfactory to note that Lord Montagu appreciates the evils of break of gauge in connection with the transportation of goods. No doubt actual transhipping arrangements could be improved to a certain limited extent.

Sir William Acworth emphasises the need for a gauge policy, and suggests that this would be fully demonstrated if the map were made to show more clearly the intersection of gauges. I hope this suggestion has been carried out in preparing the block for publication. Sir William suggests that it would be time enough to consider a policy when a programme of extensions is contemplated, as all available money is now pledged to the rehabilitation of existing systems. But, as I have already pointed out, several existing sections of metre gauge line are now faced with the alternative of doubling or conversion. It is a question, not of rehabilitation

nor of extension, but of increasing capacity to meet the growth of traffic. Pending the investigations of an expert committee, such as he recommends, such sections of line might be able to carry on a little longer with the aid of "train control" and other devices for increasing the capacity of a single track, but the ultimate policy to be adopted must be decided on, for better or for worse, in the near future. Sir William's reference to the 3′ 6″ gauge in South Africa would appear to imply that the metre gauge might meet all requirements in India. I have no personal experience of South Africa, nor of the average distances of transit there, but I believe that the country enjoys a more temperate climate than that of India, so that it does not follow that what suits one country would suit the other. Although Sir William cites the broad gauge coal trains between Calcutta and the coalfields as being no heavier than the goods trains in the Transvaal, I might suggest that the tonnage capacity of a train is not the sole measure of efficiency. The potential speed of transit is an important factor, and although in the case of the local coal trains referred to the lead is so short that the actual running speed is of small consequence, yet for long leads of several thousand miles, such as have frequently to be traversed in India, not only by coal trains, but also by trains loaded with grain and other commodities, the higher potential speed of the broad over any narrower gauge is an asset of vital importance. I am glad to note that Sir William endorses my views as to the evils of break of gauge.

As regards legislation, Sir Charles Armstrong shares Sir William's view that what is required is a policy, not legislation. But I am doubtful whether a consistent policy can be secured without legislation. Sir Charles questions my advocacy of conversion in preference to doubling in the case of a metre gauge line when the traffic has reached the capacity of a single track. My reply is that a broad gauge single track has roughly double the capacity of a metre gauge single track, and that conversion can usually be effected at slightly less cost than doubling. It is true that a double track has at least three times the capacity of a single track on the same gauge. But the point is that a metre gauge line does not require its capacity to be trebled at one step, the increased capacity resulting from conversion would suffice for at least 20 years' further growth of traffic, while the mere fact of conversion would at once confer on the railway concerned the freedom of India, so to speak, in the railway world, which would be an inestimable advantage, without incurring more expenditure than it would have to face in any case to meet its traffic requirements. It may of course be admitted that the conversion by sections of a metre gauge railway might cause some inconvenience during the transition period, but all remodelling schemes and improvements cause temporary inconvenience, the minimising of which depends entirely on the powers of organisation and administrative abilities of the executive staff. Of course, a carefully thought-out programme would have to be worked to in every case. Sir Charles' remark as to the need for quicker transit of raw materials from the interior to the coast in the interests of external trade, is an argument for an unbroken broad gauge for long distance traffic from all centres of production to the ports, for only on such conditions can the best results be obtained. He also advocates, as I do, light feeder railways for areas of very light traffic where a broad gauge would not pay, but in such cases I recommend the 2′ 6″ gauge as cheaper than the metre, restricting the use of the latter only to purely metre-gauge areas so long as such exist.

Sir Thomas Holland's remarks on the gauge question from the point of view of Chambers of Commerce are most valuable. He emphasises the importance of fostering external trade, and points out that delays in transit from the interior to the ports have the effect of paralysing trade. The remedy, therefore, is to improve the speed of transit. As regards the means of effecting this, he favours the appointment of a committee of investigation as recommended by Sir William Acworth's Commission. He shares Sir Charles Armstrong's doubts as to the efficacy of converting metre gauge lines in preference to doubling, but I have already dealt with this point in my reply to the latter. I foresee that the question of conversion versus doubling will be very controversial in individual cases, and that there will usually be a strong local temptation to double, as following the line of least resistance, regardless of whether such a course would be best in the general interests or not. It is for this reason that a clear-cut policy should be decided on in the near future, before metre gauge railways have had time to prejudice the position further by embarking on a programme of doubling. My point is that the question, being of imperial importance, should not be left to the choice of the railway concerned, and that all proposed doubling schemes should be held up at least until the special expert committee referred to has made its investigations and submitted its report. Sir Thomas Holland deprecates the suggestion that public opinion should be stirred up. But what I referred to was not public clamour, but the enlightened opinion of public men, such as those who have taken part in this discussion, and public bodies such as the various Chambers of Commerce, etc.

Mr. F. J. Waring appears to be a more ardent supporter of uniformity than I am myself, for he would have nothing but the 5′ 6″ gauge, even for lines of light traffic. This is no doubt a counsel of perfection, but the diagram, fig.2, I think, fully explains by the logic of capital and interest, why in cases of very light traffic in easy country the choice may sometimes

lie between a 2′ 6″ gauge line and no line at all. With the recent development of road transport it is possible that in certain districts where roads can be easily and profitably constructed for facilities of administration road motor vehicles may take the place of light feeder lines to a great extent. It should be noted that the essence of my scheme is that all minor lines should be converted to broad gauge as soon as the traffic is sufficient to justify such conversion.

Mr. Sidney Preston's deprecation of the adoption of the 2′ 6″ gauge is partly answered in my reply to Mr. Waring. I am not enamoured of narrow gauge lines, but I am not apprehensive of their powers for evil. Mr. Preston refers to the Shahdara-Saharanpur 2′ 6″ line as an anomaly. But I would point out that criticism directed against a particular line because it happens to be on the 2′ 6″ gauge is no argument against the occasional use of 2′ 6″ gauge lines as feeders under any circumstances as part of a general policy. Mr. Preston may not be aware that in this particular case as in many other cases the line was required to be located so as to be easily convertible to broad gauge if so required by the Government of India. As regards the increasing mileage of the 2′ 6″ gauge, it should be remembered that a mile of narrow gauge railway has only about one sixth the capacity of a mile of broad gauge railway, single track, and only about one-third of the potential speed. These combined limitations will prevent it from ever becoming a main gauge, and will thus automatically preclude its use in areas of heavy traffic where a break of gauge would be a serious consideration. For the evils of break of gauge at a given point may be reckoned as proportionate to the amount of tonnage transhipped at that point.

Mr. Ryan, while advocating the ultimate conversion of all minor gauge railways to the 5′ 6″ gauge, favours the development of road motor transport in place of feeder lines, the power to be derived from indigenous sources. It is interesting to learn that proposals in this direction are being made in the Bombay Presidency, and it is to be hoped that the result will be successful.

In conclusion I take the opportunity again to thank Sir Thomas Bennett and Sir Lionel Jacob for their kind remarks, and the meeting for their cordial reception of the paper. I also wish to add my personal thanks to Sir Robert Gillan for having so kindly and so ably acted as Chairman.

OIL BEARING NUTS IN GUATEMALA.

The royal palm tree, especially the varieties bearing corozo and cohune nuts, grows extensively in the coastal regions of Guatemala, and although as yet little industrial use has been made of these oil-bearing nuts, they might, writes the United States Consul at Guatemala City, become the source of an important vegetable oil industry, not only because of the great quantity of the nuts in the country, but also because of the fact that the oil content of the Guatemalan kernels is understood to be 65 per cent., in comparison with 42 per cent. for African nuts. The yield of kernels per ton of nuts in Guatemala is about 18 per cent.

On the north coast of Guatemala 60,000 tons of cohune nuts are said to be available for exportation annually and with a small expenditure on road improvement this quantity could probably be increased to 100,000 tons per annum. On the Pacific or south coast the yield of corozo nuts, it is estmiated, could easily be increased to 300,000 tons per annum. There is a supply of cheap labour in this southern region.

These nuts are found almost entirely on private lands. The right to gather them is obtained from the owners by a contract, usually covering a number of years. The lack of a suitable machine for cracking the nuts or extracting the oil has been the cause of the slow development of the industry. A machine recently invented which cracks 10 nuts simultaneously has an output of about 1 ton of kernels per day. There is no plant in Guatemala for the extraction of the oil from the kernels.

PHOSPHATE PRODUCTION IN EGYPT.

The most important phosphate deposits in Egypt are found in the district of Salaja, at Kosseir on the Red Sea, and at Sabai in Upper Egypt near Keneh. According to a report by the United States Consul at Alexandria, the actual exploitation of the phosphic beds in Egypt did not begin until 1908, when the output amounted to only 700 tons. This increased rapidly, being 1,000 tons in 1909 and more than doubling in 1910, in which year the output amounted to 2,397 tons. A further gain was shown in 1911 with an output of 6,425 tons, but the effect of development was not actually apparent until 1912, when the output reached 69,958 tons. Following that year, rail connection was established with some of the mines, with the result that Egyptian phosphate entered into foreign trade, and Egypt became a factor in the world's supply. The exports of phosphates in 1913 amounted to 64,183 metric tons, valued at £64,000.

No development was reported during the years of war, but since the signing of the armistice and the supply of adequate shipping facilities, the industry has rapidly advanced until the 1920 exports (145,072 metric tons, valued at £400,000) were nearly double those of 1919 (78,425 metric tons valued at £156,000), during which year they were greater than during any preceding year.

HYDRO-ELECTRIC POWER DEVELOPMENT IN LATVIA.

The Latvian Government is in possession of various plans for the installation of hydro-electric stations on the Duna (Dvina) River, which, for the most part, were developed by engineers of the Imperial Russian Government prior to the war. These plans constitute a somewhat complete scheme for utilizing the power of the Duna and also for developing the river, through a system of locks and short lateral canals, to make it navigable well into the interior of Russia proper, and eventually, through a system of canals connecting with the Dnieper and other Russian rivers, to form an elaborate system of internal water transportation.

According to a report by the United States Trade Commissioner at Riga, the plans contemplate the eventual installation of five stations on the Duna River to a distance of approximately 65 miles upstream from Riga. Their situation, proposed installation, cost of construction (including power stations and locks) estimated on a gold rouble basis of 1914, together with estimated cost per kilowatt on like basis, are as follows, starting with the station nearest Riga :—

Stations.	Proposed installation.	Total cost.	Cost per kilowatt.
	Kilowatts.	*Russian roubles.*	*Russian roubles.*
Dahlen	24,000	10,200,000	425
Keggum	36,000	12,700,000	350
Ascheraden	16,000	5,000,000	320
Kokenhusen	80,000	14,000,000	175
Stockmannshof	36,000	11,700,000	325

Of these five projects, the two most seriously discussed for the immediate future are the station at Dahlen, to be utilized for the city of Riga and its industries, and the station of Kokenhusen, to be utilized largely or entirely for railway electrification. Without thorough study, adds the Trade Commissioner, it is impossible to say whether the market for electric power and the other relevant considerations would justify large expenditures in such undertakings; but at least the projects are such as to merit very serious consideration.

The station at Kokenhusen is linked up with the plans to electrify the government railways.

GENERAL NOTE.

Dyes from Kaoliang Bran.—According to a report by the United States Consul at Dairen (Manchuria), a method of securing dye from kaoliang bran has been discovered by mixing it with soda, sulphate, etc. The brown and black dyes produced by this process have been patented and a patent has been applied for to cover blue-black. Kaoliang bran may be obtained in practically unlimited quantities in Manchuria, delivered at stations of the South Manchuria Railway, at approximately 1.80 yen per 100 kin. The cost of production of black dyes is about 15 yen per 100 kin, to be sold at 25 yen per 100 kin; of brown dyes, about 60 yen per 100 kin, to be sold at 70 yen per 100 kin; and of blue-black dyes, about 25 yen per 100 kin, to be sold at 35 yen per 100 kin. (The present value of the yen is about 2s. 1½d., the kin is equal to 1.32 pounds).

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Monday, June 19 University of London, at Gray's Inn Hall, Gray's Inn, W.C., 4.45 p.m. Hon. J. M. Beck, "The Nature of American Institutions and their bearing on International Relations." (Lecture III.)

Tuesday, June 20 . Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.15 p.m.

Mining Engineers, Institution of, at the Cutlers' Hall, Sheffield, 11 a.m. Annual General Meeting. 1. Mr. E. Davies, "The Air-cooling Plant at the Morro Velho Mine, Brazil." 2. Discussion on paper by Dr. W. H. Hatfield, "Stainless Steels."

Anglo-French Society, Scala House, Tottenham Street, W., 6.15 p.m. M. Maurice Thiéry, "Le Théâtre de François de Curel."

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. 1. Annual General Meeting. 2. Dr. G. MacDonald, "The Building of the Antonine Wall; A Fresh Study of the Inscriptions."

Wednesday, June 21 Mining Engineers, Institution of, Cutlers' Hall, Sheffield, 10 a.m. Annual General Meeting (continued). 1. Messrs. H. Rhodes and M. Rhodes, "Methods of Working the Barnsley Seam of the South Yorkshire Coalfield." 2. Mr. J. I. Graham, "Rock Temperatures in the Coal-measures." 3. Mr. A. P. Veale, "The Rate of Absorption of Poisonous Amounts of Carbon Monoxide by the Blood."

University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Prof. Dr. A. A. H. Van Den Bergh, "The Pathology of Hæmoglobin."

Meteorological Society, 49, Cromwell Road, S.W., 5 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Mr. W. H. Bidlake, "The Continuity of English Architecture."

Constructive Birth Control and Racial Progress, Society for, Essex Hall, Essex Street, W.C., 8 p.m. Dr. C. W. Saleeby, "Birth Control and Eugenics—My Hopes and Fears."

Microscopical Society, 20, Hanover Square, 8 p.m. 1. Mr. A. Chaston Chapman, "The Use of the Microscope in the Brewing Industry." 2. Mr. A. Brooker Klugh, "The Plunger-Pipette." 3. Mr. E. A. Spaul, "The Gametogeneis of *Nepa cinera* (Water Scorpion)." 4. Mr. James Strachan, "The Microscope in Paper Making."

Thursday, June 22 . Royal National Pension Fund for Nurses, at the Royal Society of Arts, John Street, Adelphi, W.C., 4 p.m.

Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Botanic Society, Regent's Park, N.W., 6 p.m.

Friday, June 23 Physical Society, Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.

Journal of the Royal Society of Arts.

No. 3,631. VOL. LXX.

FRIDAY, JUNE 23, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

FINANCIAL STATEMENT FOR 1921.

The following statement is published in this week's *Journal* in accordance with Sec. 40 of the Society's By-laws:—

INCOME AND EXPENDITURE ACCOUNT.

January 1st to December 31st, 1921.

Dr.

	£	s.	d.	£	s.	d.	£	s.	d.
To *Journal*, including Printing, Publishing and Advertisements				4,030	13	0			
„ Library and Bookbinding				124	12	6			
„ Medals:—									
Albert	23	8	0						
Society's	39	11	0						
				62	19	0			
„ Sections:—									
Dominions and Colonies	99	8	0						
Indian	145	5	0						
				244	13	0			
„ Cantor Lectures				196	17	6			
							4,659	15	0
„ Expenses of Examinations							8,571	18	4
„ House:—									
Rent, Rates, and Taxes				1,065	4	11			
Insurance, Gas, Coal, Expenses and Charges incidental to Meetings				608	13	3			
Repairs				110	19	3			
							1,784	17	5
„ Office Expenses:—									
Salaries, Wages, and Pensions				3,336	0	3			
Stationery and Office Printing				691	9	3			
Advertising				25	17	6			
Postages, Parcels, and Messengers' Fares				358	8	7			
							4,411	15	7
„ Committees:—									
General Expenses							45	2	0
„ Juvenile Lectures							18	11	0
							19,491	19	4

Cr.

	£	s.	d.	£	s.	d.
By Subscriptions	7,005	0	3			
„ Life Compositions	520	16	0			
				7,525	16	3
„ Interest and Dividends on Society's Investments	395	6	8			
„ Ground Rents	352	10	8			
„ Interest, Dividends, and Ground Rents from Trust Funds for General Purposes	498	14	0			
Do. from Building and Endowment Funds	22	7	5			
				1,268	18	9
„ Sales, etc.:—						
Journal	360	13	5			
Do. Advertisements	521	3	3			
Cantor Lectures	15	5	11			
				897	2	7
„ Examination Fees and Advertisements in and Sale of Examination Papers				9,080	18	9
„ Charges for Expenses for the use of Meeting Room				313	8	0
„ Balance, being Excess of Expenditure over Income transferred to Capital Account (see Balance Sheet)				405	15	0
				19,491	19	4

TRUST INCOME AND EXPENDITURE ACCOUNTS.

Dr.

	£	s.	d.
To Balance forward	542	7	3
	£542	7	3

Cr.

	£	s.	d.	Trust Accumulations, Dec. 31st, 1920. £	s.	d.
JOHN STOCK TRUST—						
By Balance, January 1st, 1921 ..	25	6	1			
,, Interest on Investments......	3	10	2	28	16	3
NORTH LONDON EXHIBITION TRUST—						
,, Balance, January 1st, 1921 ..	41	4	7			
,, Interest on Investments	6	14	10	47	19	5
DR. ALDRED'S TRUST—						
,, Balance, January 1st, 1921 ..	39	0	9			
,, Interest on Investments	7	14	5			
	46	15	2			
Less cost of Dr. Myers's lecture	10	0	0	36	15	2
THOMAS HOWARD'S TRUST—						
,, Balance, January 1st, 1921 ..	97	0	0			
,, Interest on Investments	19	19	8			
	116	19	8			
Less cost of Mr. A. E. Chorlton's lectures	53	7	6	63	12	2
OWEN JONES MEMORIAL TRUST—						
,, Balance, January 1st, 1921 ..	58	10	5			
,, Interest on Investments	15	13	4			
	74	3	9			
Less cost of prizes and medals..	70	13	1	3	10	8
MULREADY TRUST—						
,, Balance, January 1st, 1921 ..	57	16	9			
,, Interest on Investments	5	5	4	63	2	1
DR. SWINEY'S TRUST—						
,, Balance, January 1st, 1921 ..	80	0	0			
,, Ground Rents (Income from) ..	180	0	0			
	260	0	0			
Less Transfer to the Society's Income and Expenditure Account	140	0	0	120	0	0
FRANCIS COBB TRUST—						
,, Balance, January 1st, 1921 ..	29	15	9			
,, Interest on Investments	8	18	10	38	14	7
LE NEVE FOSTER PRIZE TRUST—						
,, Balance, January 1st, 1921 ..	19	3	4			
,, Interest on Investments	5	16	0	24	19	4
FOTHERGILL TRUST—						
,, Balance, January 1st, 1921 ..	35	7	0			
,, Interest on Investments	13	12	5	48	19	5
TRUEMAN WOOD LECTURE TRUST—						
,, Interest on Investments	32	14	8			
Less cost of Sir Daniel Hall's Lecture (including printing)	32	14	8	–	–	–
BENJAMIN SHAW TRUST—						
,, Balance, January 1st, 1921 ..	4	16	2			
,, Interest on Investments	4	13	6	9	9	8
CANTOR TRUST—						
,, Interest on Investments	139	11	4			
,, Ground Rents (Income from) ..	141	0	0			
	280	11	4			
Less Transfer to Society's Income and Expenditure Account	280	11	4	–	–	–
DAVIS TRUST—						
,, Interest on Investments	78	2	8			
Less Transfer to Society's Income and Expenditure Account	78	2	8	–	–	–
SIR GEORGE BIRDWOOD MEMORIAL TRUST—						
,, Interest on Investments	36	15	0			
Less Cost of Sir E. Grigg's Lecture (including printing)	36	15	0	–	–	–
RUSSIAN EMBASSY PRIZE TRUST—						
,, Interest on Investments				5	0	0
DR. MANN TRUST—						
,, Interest on Investments				51	8	6
				£542	7	3
1922. Jan. 1. By Balance brought forward				£542	7	3

BALANCE SHEET, December 31st, 1921.

Dr.

	£	s.	d.	£	s.	d.
To Capital Account—						
As on January 1st, 1921	28,966	15	9			
Less Income and Expenditure Account Balance	405	15	0			
				28,561	0	9
„ Trust Funds :—						
Capital Account........	16,899	7	5			
Accumulations under Trusts Income and Expenditure Account	542	7	3			
				17,441	14	8
„ Sundry Creditors				3,250	8	6
				£49,253	3	11

The donations received in 1921 on account of the Fund for the purchase of the Society's House are not included in the accounts for that year, being treated as a separate fund. It is proposed to embody them in 1922, when the building was purchased.

Cr.

	£	s.	d.	£	s.	d.
By Investments (see Schedule)—				17,186	0	5
„ Property of the Society (Books, Pictures, etc.)				10,000	0	0
„ Trust Funds Investments (at cost, see Schedule)				16,899	7	5
„ Ground Rents outstanding :—						
Trust Account	94	18	0			
Society's Account	164	18	0			
				259	16	
„ Subscriptions Outstanding				2,923	0	
„ Sundry Debtors :—						
Journal	97	5	2			
Advertisements.........	264	19	5			
Repayment of Expenses for use of Meeting Room	174	16	0			
Income Tax recoverable	114	4	2			
				651	4	9
„ Paid on account of 1922 Examinations				900	0	0
„ Cash at Bank on Current Account (*less* cash in transit)				433	15	4
				£49,253	3	11

We have audited the above Accounts and Balance Sheet for 1921 *with the books, accounts and vouchers relating thereto, and certify them as being in accordance therewith. We have verified the Bank Balances and investments.*

KNOX, CROPPER & Co.,
Chartered Accountants

Spencer House, South Place, E.C. 2.
16th June, 1922.

SCHEDULE OF THE SOCIETY'S INVESTMENTS.

				£	s.	d.
			Ground-rents (amount invested)	£10,496	2	9
£217	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	158	8	0
£500	0	0	New South Wales 4 per Cent. Stock	445	0	0
£500	0	0	Canada 3½ per Cent. Stock	360	0	0
£100	0	0	Queensland 4 per Cent. Stock	80	0	0
£530	10	1	New South Wales 3½ per Cent. Stock	456	5	0
£500	0	0	Natal 4 per Cent. Stock	400	0	0
£321	15	9	Metropolitan Water Board "B" Stock	196	6	0
£6	0	0	New River Company Shares	6	0	0
£3,408	14	6	India 3½ per Cent. Stock	2,317	18	8
£500	0	0	South Australia 4 per Cent. Stock	400	0	0
£2,000	0	0	War Loan 5 per Cent..	1,900	0	0
				£17,186	0	5

The Investments are as valued on May* 31*st*, 1917, *with the exception of War Loan, which is at cost.

TRUST FUNDS INVESTMENTS SCHEDULE.

	£	s.	d.
Alfred Davies Bequest	£1,953	0	0
Mr. Swiney's Bequest	4,477	10	0
Mr. Cantor's Bequest	2,695	11	3
Mulready Trust	105	9	9
Howard Trust	571	0	0
Owen Jones Trust	522	3	2
Mr. Cantor's Bequest	3,273	16	6
	648	19	7
J. Murray and others, Building Fund	20	16	4
	38	11	0
Francis Cobb Trust	255	14	1
Le Neve Foster Trust	105	11	7
	42	2	1
John Stock Trust	70	4	0
Shaw Trust	93	12	0
North London Exhibition Trust	134	17	0
Fothergill Trust	272	7	6
Aldred Trust	154	8	0
Endowment Fund	394	7	0
"Trueman Wood" Lecture Endowment Fund	654	15	7
Sir George Birdwood Memorial Fund	734	19	9
Russian Embassy Prize	100	0	0
Mann Trust	1,028	9	2

	£	s.	d.
Great Indian Peninsula Railway 4 per cent. Guaranteed Debenture Stock	1,800	0	0
Ground-rents (amount expended)	£4,477	10	0
Do. do. do.	2,695	11	3
National 5 per cent. War Bond, 1927	109	10	1
Metropolitan Railway 3½ per Cent. Stock	510	9	5
India 3 per cent. Stock	423	0	0
Do. do. / Bombay and Baroda Railway Guaranteed 3 per Cent. Stock	2,573	10	0
India 3½ per Cent. Stock	20	10	0
5 per Cent. War Loan	54	18	0
New South Wales 3½ per Cent. Stock 1930-50	250	0	0
3½ per Cent. War Loan	100	0	0
5 do. do.	40	0	0
5 do. do.	100	0	0
5 do. do.	129	6	8
5 do. do.	184	15	0
5 do. do.	374	0	0
5 do. do.	210	17	6
5 do. do.	525	2	3
National 5 per Cent. War Bonds 1928	654	18	0
5 per Cent. War Loan	674	0	0
5 do. do.	91	9	3
5 do. do.	900	0	0
	£16,899	7	5

NOTICE.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One hundred-and-Sixty Eighth Annual General Meeting, for the purpose of receiving the Council's Report and the Financial Statement for 1921, and also for the election of Officers and new Fellows, will be held, n accordance with the By-laws, on Wednesday, June 28th, at 4 p.m.

(By order of the Council)

GEORGE KENNETH MENZIES,

Secretary.

PROCEEDINGS OF THE SOCIETY.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 3RD, 1922.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

THE CHAIRMAN, before the reading of the paper, said that it was scarcely necessary for him to introduce Mr. Noel Heaton, who had given numerous lectures in that hall. On a previous occasion Mr. Heaton had told them many interesting things about the pigments used in ancient times. That evening he was to essay the more difficult task of foretelling what he thought might become one of the great pigments of the future.

The paper read was :—

THE PRODUCTION OF TITANIUM OXIDE AND ITS USE AS A PAINT MATERIAL.

By NOEL HEATON, B.Sc.

Some 12 years ago I had the pleasure of bringing before the Society some investigations I had made into the pigments used by painters before the dawn of history, and expressing my views as to the methods employed by that remarkable school of painting, which flourished in Crete in the early Bronze Age.* In the present paper I have jumped to the opposite extreme; my rashness increasing rather than diminishing with age, I am forsaking the fairly safe ground of archæological research to adopt the hazardous rôle of the prophet. I propose, in fact, to discuss the latest addition which research has contributed to the palette of the painter and to submit

*The Mural Paintings of Knossos—*Journal of Royal Society of Arts*, January 7th, 1910.

to your criticism the reasons which lead me to make the bold and perhaps rash assertion that this recently discovered pigment is destined to play a prominent, if not fundamental, part in the future as a material both for the painter of pictures and the painter of houses.

For many generations past the fundamental pigment for the production of paint of all types has been white lead; for many years past there has been a growing demand for the suppression of this material on account of its alleged danger to health. Whatever may be the merits of the case, they do not concern us in the present paper; my only reason for referring to the matter being that whilst white lead has remained up to the present time the most important pigment, particularly for architectural painting, because no really satisfactory alternative has been forthcoming, this demand for its suppression stimulated research in hitherto unexplored directions with the view to finding a new white pigment which could efficiently take its place. The attempt to prohibit the use of white lead has thus led indirectly to the development of titanium oxide as an industrial material.

Before I go any further, however, with the indulgence of those present to whom such matters are perfectly familiar, I propose to answer the question which is quite naturally asked by anyone who does not happen to have studied chemistry—what *is* titanium?

In 1791 the Rev. William Gregor (1), clergyman by profession and scientist by inclination, published (2) an analysis of a black sand which he found near the village of Menaccan, in Cornwall, where his parish was situated. This substance he found to contain nearly half its weight of a metallic oxide as yet unknown to science. Almost simultaneously Klaproth announced his discovery of the compound of a new element in a red schorl from Hungary and recognised it as identical with the substance isolated by Gregor. Klaproth gave this new metal the name of Titanium.(3) It was not until 1824 that Berzelius prepared the metal itself and showed it to be a dark grey substance somewhat resembling iron in appearance, although far different from it in properties, particularly as regards the fact that it is practically infusible. From that day to this titanium has remained to all intents and purposes a scientific curiosity, although some of its compounds are used industrially to a certain extent; and it is popularly classed as one of the rare elements. And yet, by a curious paradox, as a matter of fact, it is one of the most abundant substances on the face of the globe!

One of my earliest recollections as a student is that of a lecture by Sir William Ramsay on the composition of the earth's crust, in which he pointed out that after oxygen, silicon, nitrogen and sulphur, the fifth most abundant element in nature is this "rare" and little known metal titanium; and he predicted that some day it would be as familiar to us as aluminium, unknown a generation or so ago and to-day a household necessity.

The metal itself is never found in nature, but as oxide it is present in small amounts in almost all rocks, whilst it forms the principal constituent of several minerals, such as *rutile*, *anatase* and *brookite*. It occurs most abundantly, however, in combination with oxide of iron as titaniferous iron ore or *ilmenite*. Varieties of this mineral are found in various parts of the British Isles and enormous deposits exist in many parts of the world. It is of interest to note in passing, that the beautiful but little used precious stone known as *sphene*, remarkable for its optical properties, is a compound of silica, titanium and lime.

Although titanium oxide is most often found in association with oxide of iron, it bears little relation to it in its properties, which in some respects resemble oxide of tin and in others are closely akin to silica.

According to Washburn, the first use of titanium compounds as pigments seems to have been made by Dr. John Overton, of Louisville, U.S.A., about 1870. He described a process for the manufacture of titanium pigment from pure rutil as follows:

"Rutil is ground or reduced to a sufficiently fine powder, and is mixed and thoroughly incorporated with coal tar, bitumen or other liquid bituminous materials or compounds. The mixture, when completed, forms a paint which may be employed for painting ships' bottoms and other surfaces exposed to the action of sea water."

(1) See Biographical notice in Annals of Philosophy, 1818, p. 112.

(2) Journal de Physique, 1791; see also Crells' Annalen, 1791 1 40, p. 103.

(3) "Whenever no name can be found for a new fossil which indicates its peculiar properties, I think it best to choose such a denomination as means nothing of itself and thus can give rise to no erroneous ideas. In consequence of this I shall borrow the name for this metallic substance from mythology and in particular from the Titans, the first sons of the earth. I, therefore, call this new metallic genus Titanium."—Klaproth, Analytical Essays, 1801, p. 210.

Dr. Overton claimed that his product was unaffected by salt water, formed a perfect protection for ships' bottoms and further that it was not injuriously affected by the heat of the sun, or by a temperature of 450° C.

This process did not meet with any success, the reason probably being the undesirable colour of Rutil and the great difficulty experienced in pulverising such a hard material.

The fact that titanium oxide could be obtained as a white powder which possessed in a quite abnormal degree the physical property of opacity, which should render it peculiarly useful as a pigment, has long been known, but until a few years ago it had remained unexploited.

It was not until some ten years ago that the problem of harnessing this material to industry was successfully investigated, and as so often happens in such cases, the industrial production of titanium oxide on the large scale and its application to the paint industry was started almost simultaneously as a result of researches carried out independently and as far apart as America and Scandinavia.

In the United States a pigment prepared by extracting the titanium oxide from titaniferous iron ore and combining it with calcium sulphate was introduced some eight years ago by A. Rossi and L. E. Barton. My first introduction to the possibilities of titanium white as a pigment was in 1917, when I visited Washington whilst on military duty in America. Whilst there I called at the Institute of Industrial Research and was shown by Mr. H. A. Gardner some exposure tests he had been conducting with this pigment, but I must frankly confess that at the time I was rather sceptical as to its possibilities.

Meanwhile, Dr. Jebsen and Professor Farup had been for some years perfecting a process for extracting titanium oxide from the titaniferous iron ore which is found in great abundance in Norway, notably in the neighbourhood of Stavanger, where it has been estimated that 30 million tons are available.

In 1870 this deposit was exploited by an English Company and imported to this country for use as an iron ore. It was found, however, that the high content of such an infusible material as titanium made the smelting of the ore an extremely difficult matter, and after some years' trial the attempt to utilise it in this manner was abandoned as impracticable.

About 1908, the perfecting of the electric smelting process suggested the possibility of developing an iron industry in Norway, where electrical energy is so readily obtainable. Attention was thus directed again to this titaniferous ore, but Jebsen and Farup, knowing the difficulties in the direction of utilising it as a source of iron, started investigations with a view to utilising the titanium, rather than the iron, as the principal objective.

In the course of their investigations their attention was drawn to the remarkable opacity of titanium oxide and its probable value as a pigment. Realising the great industrial possibilities in this direction, they determined to concentrate their energies on the problem of devising an economical process of preparing the oxide on a large scale, at the same time studying exhaustively its utilisation as a pigment.

Then ensued a laborious series of researches, extending over some six years, before a satisfactory process was finally elaborated; trials of its application on an industrial scale were started in 1914. As everyone knows who has studied such matters, this translation of a process from the laboratory to the factory is the most critical and arduous part of its development and four years of untiring research elapsed before the various technical and mechanical difficulties were overcome.

One cannot but admire the magnificent courage with which the inventors, encouraged by the successful results they obtained on a small scale during this period, finally decided to put their convictions to the test by planning and erecting a plant capable of producing 8,000 tons per annum, which commenced operations in 1919.

Finally, the independent workers in Norway and the United States discovered one another, and decided on a mutual exchange of their respective experiences which resulted in a further perfecting of their processes and a more complete study of the many scientific points involved.

A description of the preparation and properties of the pigment was published in a paper read before the Paint and Varnish Society last year by Mr. W. F. Washburn,* from which paper I have derived some of

* W. F. Washburn and J. McGougan. Titanium White, its Production, Properties and Uses. Proceedings of the Paint and Varnish Society, March, 1921.

the data included in the present paper.

Considerable interest was aroused by the publication of this paper, but like a good many others I was still somewhat sceptical as to the properties claimed for this new product. In February of this year, however, I had the opportunity of visiting Norway and studying the process as carried on there in detail, with the result that I have formed the opinion I expressed at the commencement of this paper.

The process of manufacture of this interesting pigment, as now established in Norway, is a most ingenious one, and I will now show you a series of slides which illustrates its main principles.

The titaniferous ore found near Egersund, south of Stavanger, consists mainly of a variety of ilmenite, to which the formula $Fe(Mg)\ TiO_3 + 10\ Fe_2O_3$ has been assigned, together with associated minerals, principally magnetite, hypersthene, and apatite, with a small quantity of vanadium. This crude ore is first freed from these associated minerals and impurities by mechanical treatment at the mines, and the concentrate, which contains titanium oxide to the extent of 4[illegible].5 per cent. is sent to the factory for treatment.

The first process in the manufacture is to reduce the concentrate to a state of fine powder by pulverisation in a ball mill. This powder is then mixed with concentrated sulphuric acid to the consistency of paste. On heating this mixture a violent reaction commences, which once started proceeds exothermically, with the result that the mineral is entirely decomposed and converted to a mass containing soluble sulphates of iron and titanium, which sets up into the form of a hard cake. This cake, or "coagulated mass," as it is technically termed, is then reduced to powder by means of a disintegrator and extracted with water, a solution being thus obtained of iron and titanium sulphates.

Owing to the fact that the salts of titanium are very unstable, it having, in fact, as much tendency to act as an acid as a basic radicle, on heating this solution nearly to boiling point for some hours, the titanium sulphate breaks down and titanic acid is thrown down from the solution as a white precipitate leaving the ferrous sulphate in solution. By this ingenious means the titanium can be completely separated from the iron, all that is necessary being to subject the precipitate to a thorough process of washing. Owing to the fact, however, that the precipitate of titanic acid is in such an extremely fine state of division that it will pass through any filter cloth, the ordinary method of collecting and washing the precipitate by means of the filter press cannot be utilised, and the more costly and elaborate method of washing by decantation has to be resorted to.

If the pulp thus obtained after removing as much water as possible by this means is merely dried an amorphous product is obtained, consisting of titanium hydrate with a small proportion of acid sulphate of titanium and free sulphuric acid. This product does not form a reliable pigment as its opacity is not fully developed, and being a hydrate it is not perfectly stable in presence of organic bodies such as linseed oil.

In order to develop the physical condition required, the pulp is, therefore, passed into a rotary furnace of a type similar to that used for cement, where it is in one operation dried and calcined to a high temperature. By this means the titanic acid is converted to anhydrous titanium oxide and changed from the amorphous state to a cryptocrystalline condition. The titanium oxide comes out of the furnace in the state of small friable nodules, which are finally pulverised and converted into an extremely fine powder by a process of air flotation.

The manner in which the calcination process is carried out is of great importance, and careful control is necessary. It is essential to carry it far enough to convert all the titanium from the amorphous to the crystalline condition, but at the same time it must not be carried too far, otherwise crystalline form as well as structure will be developed, which would ruin the product by rendering it gritty. The essential point is to change the internal structure of the particles without altering the size and shape in which they are precipitated.

It was found by experience, however, extremely difficult to control the reaction to this nicety on the large scale if a precipitate containing pure titanium was employed. In order to prepare the titanium pigment—which is known as "titanium white" to distinguish it from the pure oxide —further modifications in the process of preparation were found to be necessary. As a result of careful research on this point, it was found that by precipitating the titanium together with barium sulphate a physical

combination of the two is formed, which is more easily controlled on calcination than the pure oxide and, at the same time, is very much more economical to produce. It has been found that the most efficient combination of these two substances for most purposes is that containing equal equivalents of each, that is to say, one molecule of titanium oxide in combination with one molecule of barium sulphate or, by weight, titanium oxide 26.5% and barium sulphate 73.5%. Pigments containing a higher or lower percentage of titanium can, however, be produced at will.

In practice the pigment is produced in two strengths—one containing the two materials in the above proportions—roughly, 25% of titanium oxide, which is the standard product. The other, which is used for special purposes, contains a much lower proportion of barium sulphate, and the maximum content of titanium which can be satisfactorily used. To distinguish between these two varieties I will refer to them when necessary as standard titanium white and extra titanium white respectively. It will be noted that the large proportion of barium sulphate present, particularly in the case of the standard grade, is an essential part of the pigment and in no sense an adulterant as in the case of a mechanical addition of barytes. Such a mechanical mixture would not give the required properties. In fact, the purity and physical condition of the barium sulphate is of great moment in the production of these pigments.

Theoretically, one would imagine that the best way to form this combination would be to precipitate the titanium and barium simultaneously, but in practice there is a risk of bringing down some of the iron if this is done, and it is found preferable to form the barium sulphate first and add it in the state of pulp to the solution and precipitate the titanium on it by the process just described. After the combined precipitate has been washed free of iron and before it is transferred to the furnace, a small proportion of barium carbonate is added to it in order to insure that every trace of free sulphuric acid is neutralised by conversion into barium sulphate, as this would obviously be objectionable in the pigment.

The pigment as produced by this process in the early days was not quite perfect in colour, having a yellowish cast, which, at the time, was attributed to the fact that the iron was not entirely removed. Thus, Coffignier, in his book, "Couleurs et Vernis," published last autumn, writing on titanium white, states as follows:—

"Le produit commercial est une poudre blanche, qui manque un peu de pureté car elle contient une trés faible quantité d'oxide de fer," and he goes on to predict a great future for it if this objection could be removed.*

It was found, however, that after taking every possible precaution to free the product from the least trace of iron, it was impossible to prevent it turning slightly yellowish in colour during the process of calcination, and it was eventually discovered that the very natural assumption that this discoloration was due to a trace of iron was, as a matter of fact, absolutely incorrect. As a result of careful research, it was proved that it was due to a molecular change which takes place in the pigment during the process of calcination. By calcining the titanic acid to a sufficiently high temperature for a sufficiently long time, it is possible, in fact, to develop in it clearly defined rutile crystals of a distinctly yellowish colour.

The problem now arose how to prevent this change taking place, and this entailed a very considerable amount of research before the very simple remedy was discovered. If a small proportion of the titanium is present in the form of phosphate, the change is, for some reason which it is very difficult to understand, entirely prevented, and a perfectly white product obtained. This discovery has only been made comparatively recently, with a result that the pigment as produced to-day is vastly superior in quality. The prediction made by Coffignier is, therefore, already in course of fulfilment, the titanium white of to-day being remarkably brilliant and pure in tone.

Titanium white as thus produced has chemical properties which render it of the utmost value as a pigment, particularly for the preparation of protective paints. Owing to the fact that titanium oxide, like silica, is the most chemically stable compound of the metal, the pigment is extremely resistent to attack by any of the destructive agencies to which it is likely to be exposed. That it will resist the attack of sulphuric acid, which is notoriously the chief destructive agent in the air of our towns, will be readily

* Charles Coffignier, "Couleurs et Vernis," p. 55.

conceded when one considers that the pigment is actually produced in the presence of free sulphuric acid. Neither is it liable to discoloration by sulphuretted hydrogen because titanium does not readily form a coloured sulphide. Being also a fully oxidised body and in the crystalline state, it is not readily attacked by sea air or salt water, which are most severe upon pigments. One would, therefore, expect great durability from paints made with this pigment, and this point has been very carefully investigated on a most elaborate scale by means of the practical exposure tests, of which I now show you illustrations.

In these tests, paints made with every available white pigment in every possible combination have been painted on boards and exposed side by side since 1918. Information as to the effect of over three years' exposure is, therefore, now available, although, as a matter of fact, the conditions of exposure have been so drastic, the boards being exposed to a direct south aspect at an angle of 45°, that I consider the weathering effect is equivalent to at least five years of exposure under ordinary conditions.

I have had the opportunity of studying these tests minutely and examining in detail the methods of preparing the paints and the precautions taken to render the data obtained reliable. It would be tedious to attempt to give in detail the mass of information resulting from them. The general results may be summarised to the effect that the paints made with titanium pigment have shown no tendency to crack or peel, but have worn down evenly and uniformly, the surface finally becoming powdery ("chalking" as it is technically termed) and remaining in an excellent condition for repainting. As a matter of fact, the most durable paint of all proved to be that prepared from a combination of titanium white with a proportion of zinc oxide. One can readily understand that this should be the case, because owing to the complete chemical inertness of titanium it does not have any hardening action on the oil, so that paints made with pure titanium are inclined to be too elastic. The well-known hardening effect of zinc on the oil, has, therefore, the effect of giving the necessary hardening to the paint, provided it is added in moderation.

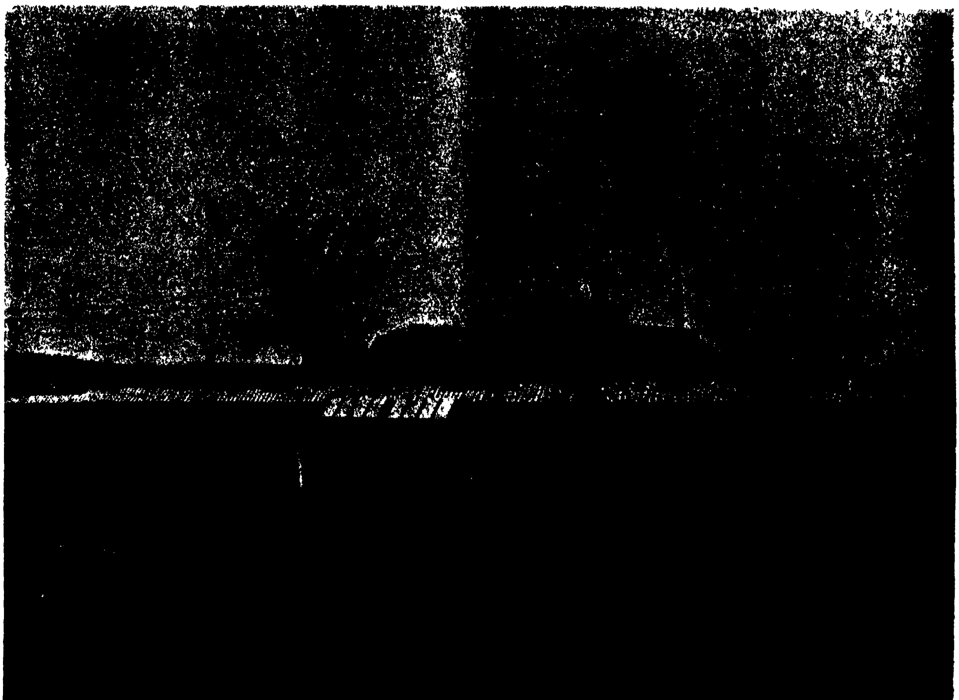


FIG 1.—General View of Exposure Tests of Titanium Paints at Fredriksstad

FIG. 2.—Detail View of Exposure Test Fence

Owing to the fact that titanium is not a definitely basic pigment like lead or zinc, but quite neutral in character, this complete inertness or lack of action on the vehicle with which it is mixed to form paint, is one of its characteristics, and for this reason it is rather slow drying in character. This is an advantage rather than otherwise, for some purposes, such as the preparation of artists' colours, but a disadvantage where the conditions of painting demand fairly quick drying, as in ordinary house painting. The preparation of paints from it which will dry in the reasonable time required by the decorator does not, however, present any serious difficulty in practice.

Owing to the chemical stability of this material, it is possible to use it for those methods of painting where none but the most permanent of pigments are admissible, such as true fresco painting, where the pigment has to stand the action of caustic lime. More important from the practical and economic point of view is the fact that on account of this chemical stability it is not readily absorbed into the system if accidentally inhaled or otherwise taken into the body by the painter in the course of his work. In order to be so absorbed it is necessary for the pigment to be re-acted upon by the gastric or other juices and converted into soluble salts, and being practically unattacked by any such solvents it passes through the system without being absorbed. Even if we assumed that it could be so absorbed, however, it is generally conceded that the soluble salts of titanium are quite harmless. One may believe, therefore, with the utmost confidence, that this pigment is absolutely non-poisonous and harmless in use, a consideration of great practical importance at the present time. As a matter of fact, one of the unlooked for and somewhat surprising uses to which it has been put for this very reason is the preparation of cosmetics and face powders.

The physical properties of this pi ment are, perhaps, even more interesting than its chemical properties; the most important from the practical point of view being its extraordinary opacity, which is greater than that of any other known white pigment. This fact is clearly demonstrated by the illustrations I now show you. It is a some-

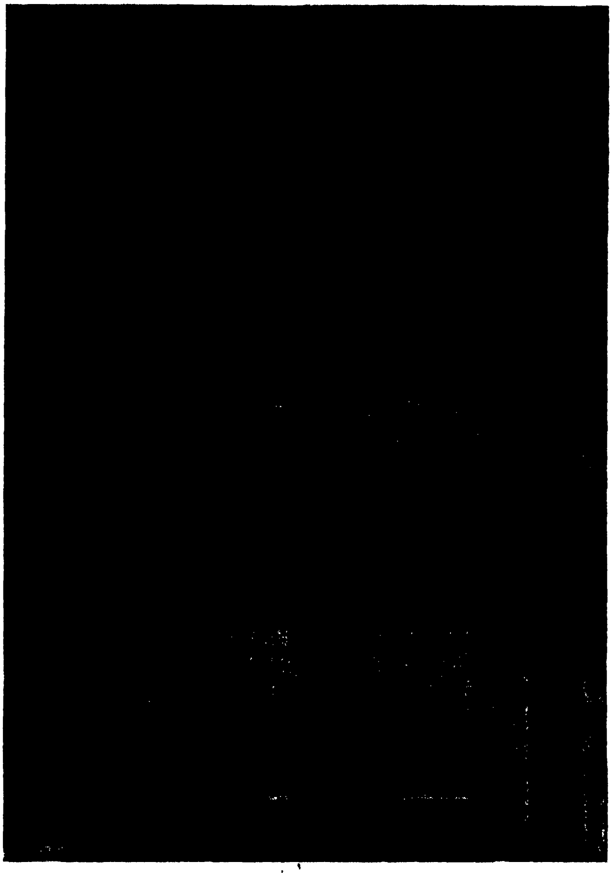


FIG. 3 — Test of Resistance of Titanium White to Corrosive Gases: Wall of Chemical Laboratory, originally painted uniform White, after two years' exposure. Ordinary White paint used *above* the line A B, paint made with Titanium White *below*.

what difficult matter to express such properties as opacity in terms of figures, but one is able to do so with a reasonable approach to accuracy by means of a little instrument recently invented by Dr. Pfund, whereby the thickness of a film of paint required to produce a definite degree of opacity can be directly measured.

By measuring in this instrument the opacity of paints made by grinding different pigments in oil in accurately determined proportions, using always exactly the same oil for the purpose, one can calculate the relative opacity of two or more pigments. Determined in this way, the opacities of the principal white pigment expressed as the relative *weights* required to produce equal obliteration of a surface, are as follows:

Extra titanium white	130
Standard titanium white	100
Zinc oxide	77
Lithopone	65
White lead	46
Basic sulphate of lead	35

It is, however, more practical to base the comparison on equal *volumes* of the respective pigments; expressed in this way the figures are quite different, owing to the difference between the specific gravity of the pigments, the figures obtained being as follows:—

Extra titanium white	140
Standard titanium white	100
White lead	88
Zinc oxide	77
Lithopone	66
Basic sulphate of lead	58

It must be admitted that this method of measurement is to some extent academical; the usual method adopted in practice

of comparing the opacity of two pigments being to make them into paint of equal consistency and paint them out over a black and white surface. Whilst I do not, therefore, lay too much stress on the above figures, the general result they show as regards the great opacity of titanium white is borne out by any form of practical trial.

The point that interests one most, however, in this connection is the *reason* for this remarkable opacity.

The opacity of any paint depends on the extent to which the light falling on it is reflected by the particles of the pigment in it instead of being allowed to pass through them and so reveal the surface beneath. This is largely influenced by two things. In the first place the smaller the size of the particles the more surfaces are presented for reflecting the light. But this by itself would be of little service unless each of these individual surfaces has a pronounced power of reflection, and the extent to which this is possessed depends on its optical properties and particularly the refractive power.

It will be seen from the accompanying table of refractive indices that that of titanium oxide is remarkably high, from which one would expect great opacity from it.

Selenium	2.92
Titanium Oxide, crystalline ..	2.71
Extra titanium white	2.60
Diamond	2.40
Zinc sulphide, crystalline ..	2.37
Zinc sulphide, amorphous ..	2.30
Standard titanium white ..	2.30
Sulphur	2.00
White Lead	1.99
Zinc Oxide	1.90
Titanium hydrate, amorphous..	1.80
Blanc Fixe	1.64
Barytes	1.63
Quartz	1.55
Linseed oil	1.49

I may say, with reference to this table that the refractive indices for the various pigments were determined by the microscopic method of making slides of the pigment immersed in a series of media, the refractive powers of which are accurately known. Mixtures of selenium and sulphur were used as immersion media for those pigments which range above 2.0, prepared according to the method adopted by the U.S. Geological Survey.*

* See American *Journal of Science*, Vol. XXXIV., July, 1912

It will be noticed as regards Titanium pigments that the method of preparation has an important bearing on this important property of opacity. During the course of the calcination process, which I have described as forming part of the preparation of the pigment, the titanium is converted from the amorphous to the micro-crystalline state, which has the effect of increasing the refractive power from 1.8 to 2.71. The extraordinary point is, however, that when the combined precipitate of titanium oxide and barium sulphate is calcined in this way the opacity of the composite product obtained is far above the mean of that of the two constituents. The theory put forward by Washburn to account for this is that on precipitation the titanium oxide forms a coating on the surface of the particles of barium sulphate. When the product is calcined and is changed from the amorphous to the crystalline state the result is that each particle of the pigment thus formed consists of highly refracting titanium oxide inter-crystallised with low refracting barium sulphate. By this means additional reflecting surfaces would be formed within each particle, and the reflective power, and consequently the opacity of the pigment thereby increased.

But I must confess that I do not know of any practical proof that this inter-crystallisation actually happens. I have made many endeavours to satisfy myself as to what really takes place, by microscopic examination, but have hitherto entirely failed to identify any definite structure of this nature. But whilst the actual cause thus remains a matter for further study, the practical fact is beyond dispute that a combination of titanium oxide and barium sulphate produced in this way has almost as great an opacity as the pure titanium oxide itself, although by itself the barium sulphate has such little refractive power as to be practically transparent in oil.

It is this high opacity which forms one of the most valuable properties of the pigment, and renders it of peculiar value for various special purposes where this quality is particularly desired, such as for the delicate hair lines of illumination work, the preparation of white printing inks and similar cases where it is required to produce an intense white colour on a dark background in one operation.

In addition to the refractive property of

the substance, its opacity is also influenced by the state of division. As mentioned in describing the method of preparation, the titanium oxide precipitate is so extremely fine in character that it cannot be filter pressed, which is a further reason for its exceptional opacity. It is, as a matter of fact, much finer than any other white pigment, the average diameter of the particles being no more than one micron.

But, to my mind, the most interesting point of all connected with the physical properties of this material is the fact that, combined with the remarkably high refractive index, it has a remarkably low specific gravity, as will be seen from the following table :—

Titanium white, extra	4.00
Barium sulphate..	4.20
Titanium white, standard ..	4.30
Lithopone..	4.30
Barytes	4.5
Zinc oxide	5.66
Basic sulphate of lead	6.41
White lead	6.81

In general, one finds that the refractive power of a substance is roughly proportional to its specific gravity. When, for instance, a substance is converted from the amorphous to the crystalline state the refractive power increases, and the change is generally accompanied by a corresponding increase in specific gravity. But if we compare, say, white lead with titanium white we find that whereas its specific gravity is considerably higher the refractive index is actually lower, although both are distinctly crystalline materials and one might, therefore, reasonably expect them to follow the same general principle as natural crystals.

It is suggestive, in this connection, to refer to the diagram published by Prof Miers in his lecture on "Precious Stones."* This shows clearly that the refractive powers of all the natural crystalline minerals used as precious stones are approximately proportional to their specific gravity, with two notable exceptions—the diamond and sphene, both of which have abnormally high refractive powers and exceptional optical properties generally. Now sphene contains approximately 40% of titanium oxide. The coincidence appears to me to be striking and confirms one in expecting the abnormal opacity of titanium oxide, which we find to be borne out in practice.

* Prof. A. H. Miers. Precious Stones. Cantor Lectures, Royal Society of Arts, 1896.

If we consider this exceptional combination of physical properties—the extreme opacity combined with the great lightness and fine state of division ; if, further, we take into consideration the durability and stability resulting from the chemical composition of this titanium product, it seems clear that it has quite exceptional possibilities as a pigment, which, in my opinion, at any rate, justify one in thinking that it is destined to become one of the most widely used and one of the most valuable materials at the service of the painter.

At present it is in its infancy, and forms a fascinating subject for research on the many technical problems with which its production and utilisation is still surrounded.

I want, in conclusion, to say a little more about titanium oxide, as distinct from the pigment produced from it.

I mentioned in describing the extraction of titanium oxide from the ore that if the pure titanium precipitate were collected and dried it would not in this state form a very reliable pigment. But if this precipitate is washed and dried at a temperature only high enough to drive off most of the combined water an amorphous titanium oxide is obtained of the following average composition :—

TiO_2	93.00
Combined water	3.25
SO_3	2.75
SiO_2	0.85
Fe_2O_3	0.13

With the same plant used for the preparation of titanium white this practically pure titanium oxide can be readily produced in large quantities. The industrial utilisation of this product is still in the research stage. Considering the enormous stores of the raw material which nature has placed at our command, the fact that it is now available in a high state of purity in quantities which are only limited by the demand, the utilisation of this substance would usefully form a subject of investigation in many industries. I have in mind, for instance, the glass industry, in which it seems to me that titanium oxide has distinct possibilities. Research in this direction has, as a matter of fact, only been held back because no available supply was forthcoming. This restriction now being removed, I believe that titanium oxide will find uses in many unlooked for directions on account of its peculiar combination of properties.

DISCUSSION.

Mr. H. O. WELLER (Director of Building Research, Department of Scientific and Industrial Research), said that, in view of the work of the H.O. Departmental Committee on Industrial Paint Dangers in which he himself was engaged, he felt that he would prefer not to make any contribution to the discussion. He could only thank Mr. Heaton very much for his interesting paper, and say that if there was a rival to white lead, he thought it was titanium oxide. He had had the pleasure of hearing Professor Jebsen give an account of his process.

SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., said that he had no ideas at all upon the subject, unlike the last speaker, who had too many. Nor had he any interest at all in any form of paint; he had much more interest in the mineral which had to be utilised in order to give rise to this product. But the paper was one of extreme interest. Mr. Heaton had drawn attention to the fact that titanium oxide was very widely distributed throughout the globe. If an element was very widely distributed, considerable difficulty often arose from its wide affections. It would associate with a very large number of other elements, and it was very difficult to dissociate it. The reason why it was widely distributed was also the reason why it was difficult to separate. Titanium was, indeed, widely distributed; in fact, it was a perfect nuisance in many economic processes, especially in iron smelting; and on account of the similarity of its properties to those of the elements with which it was associated, it was as difficult to separate as alumina from silica. Hitherto, it had been one of the greatest drawbacks that it was difficult to obtain titanium oxide in a pure form at a price that would make it useful for many applications in the arts. This difficulty, so far as it was technical, had been got over, but there still remained the economic question, and he was rather glad that Mr. Heaton had not introduced into his paper any estimates as to the cost of production, for this must be an expensive process For one thing, it was obvious that the more iron ore that was left in the crude material, the more sulphuric acid would be wasted in the subsequent process of treatment. Then there followed a whole series of processes, all of which were more or less expensive. The product, therefore, was likely to be costly. Mr. Heaton, however, had then touched the spot very cautiously, but he thought very definitely, when he pointed out that here was a product of large volume for a small amount of weight, a high degree of opacity, and, obviously, lasting qualities, which must be out of all comparison with the products which had had to be used hitherto for white paints. As an officer who happened to be responsible during the war for keeping in condition a large fleet of ships, and a still larger number of railway carriages, he realised how difficult it was to get a reliable paint seller! It was difficult to be sure that one was getting the product one paid for; but here was a product so obviously valuable that there was no doubt the chemists would soon get to work and prepare methods for the detection of adulterants, which would be the first industry that would spring up when this product got fully into operation. The paper had been of the greatest interest from the technical and scientific point of view.

MR. WALTER C HANCOCK said that Mr. Heaton had proved practically conclusively that titanium oxide was from its very nature one of the most suitable materials that could be found as a pigment. Titanium was a most extraordinarily widely spread material. Titanium oxide was extremely resistant in its action to other reagents, and in addition to its use as a pigment, it had several possibilities in application to which Mr. Heaton had alluded. The fact that titanium oxide in a very pure condition could be obtained commercially at, he took it, a reasonable price, would be welcomed by the people who were interested in the production of enamelled ware. It was one of the most useful opacifying agents available for this purpose, and was used in a good many cases for ceramic work Mr Heaton had also referred to the utilization of titanium oxide in glass manufacture. He fancied that Mr. Heaton had at the back of his mind the idea of a substitution of a large proportion of the actual silica in an ordinary silica glass by TiO_2. But the speaker would like to bring to his notice the fact that some time ago a patent was taken out—he believed in France—for the production of a material known as siloxide, prepared by fusing together a relatively large proportion of silica with a small proportion of some refractory oxide, of which two were suggested—namely titanium oxide and zirconia The properties of the resulting material were remarkable. It was extraordinarily resistant chemically, and he believed thermally, and could be worked comparatively easily, much more so than the ordinary fused silica ware. He could endorse Sir Thomas Holland's remark that titanium was a nuisance in some respects. On the other hand, he believed the melting point of pure titanium oxide to be about 1,400° C., so that if titanium oxide was procurable in suitable quantities, it was quite possible that amongst its other applications it might be used for certain refractory purposes with the limitation that refractoriness was not required beyond about 1,400° C. From the development of this and kindred processes, he thought the industrial world might reap considerable benefit.

Mr. J. Cruickshank Smith thought that many interesting points had been brought out. In the first place, he was glad to hear Mr. Heaton acknowledge so frankly the origin of much of the work he had brought before them that evening. A paper was read on this same subject about a year ago at the Paint and Varnish Society, and those who had listened to that paper recognised the inspiration of many of the statements made that evening. With regard to the subject of titanium white, he was only interested in it from the point of view of industrial painting In industrial painting every white pigment was of interest. Nearly nine-tenths of painting work was carried out by means of white pigments, and of the nine-tenths a very small part was done by professional painters --that is, craftsman painters. Most of the paint was put on by more or less unskilled people. This made it all the more important that every new pigment which was discovered and developed should be brought to the notice of the public at large The pigment which Mr Heaton had been telling them about that evening was a most important one In the first place, it was not what was so commonly and glibly called a "pure" pigment. It contained a notable quantity of so-called adulterant—namely, barium sulphate In analyses and specifications of paints and pigments one often found imposing specifications aiming at so-called purity. Now, the thing which was not wanted was purity. What was wanted was a conglomeration of properties to give a definite result This was given by titanium white. He believed that there was a great future for such a pigment, and for two reasons. In the first place, it was not a basic pigment, therefore it had not the action upon oils and other materials which was customarily associated with such pigments as white lead and oxide of zinc. In the second place, this pigment possessed great opacity. He noticed, by the way, that in the composition of the amorphous titanium oxide obtained after the precipitate had been washed and dried at a temperature only high enough to drive off the combined water a considerable proportion of SO_3 (2 75 per cent.) remained. Was it not possible to eliminate that impurity in the course of the production of the material ? He thanked the author for a most admirable and suggestive paper.

Mr. Charles Harrison said that he had listened with great interest to Mr. Heaton's lecture, and he thought that the paint and varnish trade would welcome his remarks on their publication in the *Journal*. This titanium white was an exceptional pigment. He could bear out what Mr. Heaton had said; in fact, he had himself been making a few notes concerning this pigment. He agreed with Mr. Smith that the general public should be let into the secret a little more, and he also seconded his remarks on the question of purity. An analysis which showed purity did not mean that the pigment was a good one. In fact, the mere analysis might tell one nothing. He wished to suggest a few warnings. In the first place they must not consider that titanium white was a substitute for white lead or zinc oxide or lithopone; conversely, white lead was not a substitute for titanium white, nor for zinc oxide. He had found by experience that this titanium white was an inactive pigment in the chemical sense It was a permanent white pigment, also the most opaque of white pigments. It was an accelerator of white pigments—which might be a useful property. It was unchanged by linseed and other drying oils in the passage to their solid products. It was without drying properties; was unchanged by dull red heat; also was inactive in any kind of varnish—oil or methylated spirit varnish It was inactive to all coloured pigments; coloured pigments would not interact with it It was a suitable pigment base for aniline dyes. Finally, if zinc oxide was a so-called non-poisonous pigment, then titanium white was more than its equal in this respect. Neither of them was edible! And the dust of neither should be inhaled. He believed that titanium white would be found to be one of the best of pigments when employed with common-sense.

Mr. John D. Batten said that he could only speak as a painter of pictures, but, of course, this was just the pigment painters were wanting. They had had the demerits of white lead pointed out to them, and, indeed, had experienced them; and zinc white had not filled the place. He was full of hope that Mr. Heaton would succeed in giving them the strong white pigment they were wanting in every kind of picture painting.

Mr. F. Dakin said that experience seemed to show that titanium white was very slow in drying. Was it possible for it to dry more quickly, and, if so, what drier should be applied to attain that result? With regard to its resistance to water, could wood or other similar substances be painted with titanium paint alone, without using a white lead undercoating? Was there any advantage to be obtained by mixing a certain proportion of white lead with titanium paint instead of zinc oxide, or with zinc oxide? It seemed to him that the addition of zinc oxide would have a tendency to make it less resistant to water. No mention had been made of another new pigment derived from antimony. He hoped that the lecturer would be able at some later date to give them some information as to antimony oxide for use as a pigment.

Mr. Bruce Anderson expressed his thanks to the reader of the paper, and hoped that Mr. Heaton would supplement his remarks by stating whether this titanium white could be employed as a useful basis for coloured painting work. He described a successful experience with a somewhat similar paint for use as a basis on the ironwork of gasometers.

Mr. J. A. Gibson said that he had come to the meeting as one keenly interested in the discovery of some material which should take the place of white lead, and if all was true that Mr. Heaton had told them about this material, he believed it would replace white lead in the painting trade and in this way avert considerable suffering. For this they had cause to be extremely thankful for the research work done in the laboratories. Although the production might be in its infancy and its cost considerable, the advantages of its volume and opacity had to be reckoned with, and these would go far to counterbalance the question of cost. He felt quite sure that with time the material could be perfected. Could Mr. Heaton give them any idea as to the amount of this material which might be produced from the ore available in this country? Also, as the question of opacity was of great importance it would be of interest to many of them to know how many coats would have to be put on in order to get the opacity shown in the specimen boards which the lecturer had exhibited.

The Chairman, before calling upon Mr. Heaton to reply, said that he had always understood that in the German chemical trade they tried any new product first for one purpose and then for another, and if they could find no other use for a substance they put it forward as a patent medicine! The fact that this material had absolutely no effect upon the human body would seem to make it all the better for this purpose.

Mr. Heaton, in reply, said that he considered the various speakers had been very generous in their remarks on his paper. Sir Thomas Holland had raised the question of the cost of production. That was a question which he purposely did not touch on, because he wanted to confine himself to the more technical and scientific side of the subject. But he might say that, as a commercial proposition, the speaker was perfectly correct in his suggestion that, in spite of the fact that the price per hundredweight of titanium white was comparatively high, it was actually more economical in use. This was accounted for by its properties, particularly its lightness and extraordinary opacity. Mr. Hancock had suggested what he himself was thinking of in connection with the glass industry, that here they might have to some extent a substitute for silica. Also, as Mr. Hancock said, it was rather a point in its favour that it might be used in the production of refractory materials owing to its extraordinarily high melting point. With regard to the remarks of Mr. Cruickshank Smith as to the content of barium sulphate, he thought that what Mr. Smith desired to point out was that whereas in many cases the analysis would report that barium sulphate was present in a paint, and, therefore, it would be assumed that it was an adulterant, as a matter of fact, the exact contrary might be the case, and the barium sulphate be, not an adulterant at all, but an integral part of the pigment. This was true of other pigments besides titanium white—lithopone, for instance. The barium sulphate was not added as an adulterant; it was an essential part of the pigment itself. When he used the term "barium sulphate," he meant the artifically produced barium sulphate, and not the natural product which was in crystalline form. With regard to the presence of sulphuric anhydride in the pure titanium oxide, he did not think that this was an impurity of any moment, for the purposes for which the material was likely to be used. He would emphasise, however, the fact that this impurity was carefully eliminated in the case of the pigment, which was quite another matter. Mr. Harrison and other speakers had referred to the fact that titanium oxide was not to be considered as a substitute for lead and other pigments. He desired to make it clear that the scope of his paper was confined entirely to the preparation and properties of titanium pigments—a discussion of the relative merits of different white pigments would be quite irrelevant to this purpose, and he had refrained from mentioning any other pigment, except where this was absolutely necessary in order to give some idea of the properties of the pigment with which he was dealing. Mr. Dakin asked about the slow drying of titanium; that certainly was a point to be considered. It was slower drying than white lead, but there was no difficulty in overcoming that, and the most efficient drier he had found was a combination of lead and cobalt. He had also asked whether titanium could be used as an undercoating. He wanted it to be understood that all the exposure trials to which he had referred in his paper were straight trials; the same mixture was used throughout, and the tests went to prove that it could be used all the way through, from beginning to end of the painting. Mr. Dakin had asked whether it would be of equal advantage to mix titanium with white lead instead of zinc oxide. Experience had shown that that was not the case. The combinations of titanium white with white lead did not show up nearly so well as the combination of titanium with a small pro-

portion of zinc. That experience had been confirmed in America by the Institute of Industrial Research, which published a report on that very question. This report would be found in the *Bulletin* of the Paint Manufacturers' Association. The investigators came to the same conclusion, that the mixture with white lead was not effective, whereas the mixture with zinc oxide was valuable With regard to the supply in this country, it would be governed by the demand, and be equal to the demand. As regards the opacity, the specimens exhibited had been painted with only one coat over the black line.

The proceedings concluded with a cordial vote of thanks to the author of the paper

NOTES ON BOOKS.

METRIC SYSTEM FOR ENGINEERS. By Charles B. Clapham. London: Chapman and Hall, Ltd, 1921 12*s* 6*d* net

Well meant efforts to simplify, improve or supplement our statutory metric system may be largely responsible for the existing undercurrent of opposition; moreover, the numerous "simplifications" by many writers have, in the aggregate, led to a notable degree of complication. We, however, suggest that the spirit of the tacit *Contrat Social* of Rousseau should inspire writers of books and public teachers, to respect details and forms as embodied in our national laws. At any rate, writers on the metric system would do well to verify all their data by reference to the official printed copies of statutory documents, instead of taking the too usual course of copying from other books or from the manifestos of associations or congresses.

Mr. Clapham is transparently straightforward and candid in considering the arguments for and against the metric system, and is evidently desirous of realising the utmost accuracy in every detail; moreover, he is lucid, thorough and careful in his workshop details; therefore, the book may be cordially recommended to the engineering community, notwithstanding the many departures from statutory terms or conditions, but these inconveniences may be eliminated in a second edition.

Uncertainty and redundancy centre largely on abbreviations, some 72 being tabulated on p. 5. Of these, Mr. Clapham favours or adopts 35 and rejects 37, the statutory abbreviations (grm.) for gramme being among those rejected; he prefers the shortened form g., but he expands the customary cc. to cu.cm. The present statutory spelling "gramme" for the primary unit of weight is rejected by our author (p. 3), who declares n favour of "gram," a form adopted in the Act of 1878 by its 3rd schedule, but it having been found that grain and gram may be so similar if hastily written as to involve danger in the matter of medical doses, the full spelling was restored by the Act of 1897, with its two supplements, Statutory Rules and Orders Nos. 410 and 411. On p. 67, Mr. Clapham states that the centilitre and the millilitre are superseded by the cubic centimetre; but the last mentioned Act of Parliament is against him, as it abolishes the cubic centimetre as a measure of capacity and replaces it by the nearly equivalent millilitre.

As our author touches lightly (p. 141) on the origin of a decimal basis for weights and measures, it may be mentioned that our old Roman system is decimal in its origin, like the more recent French metric system. Thus our mile is decimal in origin, and in name (*mille passus* or *mille passuum*); the steps being complete or 2-phase steps of 5-feet, but our mile appears to be nearly 100 yards over measure. In Rome, as here, the decimal mile was soon divided by repeated halvings: just as in France the pedestrian thinks, speaks and writes of quarter kilometres. Our gallon after many changes, appears now to be very near to the standard of the old Roman ten-pound gallon. Thus, our gallon of water weighs ten pounds, or 70,000 grains, and by repeatedly halving the pound of 7,000 grains, we arrive at the ounce of 437½ grains. Thus our avoirdupois ounce is not a strange unit chosen in a fit of mental alienation, but an example of the arithmetical complication which may result from repeated halving.

Vitruvius, who wrote his *De Architecturâ* about two thousand years ago, mentions the early use of ten as a basis, the reasons for favouring ten, and also Plato's advocacy of ten. Subsequently Vitruvius refers to a period when his own people (the Romans) somewhat revived decimalism by establishing a denarius consisting of ten asses, but soon there was a new unit from the denarius by quartering and thus was formed the sestertius of 2½ asses. (Vitruvius, Lib. III. Cap. I. pp. 57 to 60 of the Tauchnitz 1828 stereotyped edition) The sequel is touched on in Dr. Smith's Students' Latin Grammar, London, 1863. Appendix IV. pp. 363-364. We here read of the building of an elaborate new decimal system on the basis of the sestertius, which, in the later time of the Republic, became the unit of business calculations. The above mentioned cycle of change, decimalism, quartering, new decimalism, appears to be usual.

Considering facts and tendencies as history shows them, the suggestion made by that eminent engineer, Sir Frederick Bramwell, in a letter to the *Times* of March 20th, 1899, may be worth mention. As regards our two systems (Roman and French), he says "Let the two exist together and experience will prove which is the one preferred by the community."

OBITUARY.

WILLIAM NEWTON BEST, M.Am.S.Mech.E.—The death took place on April 11th, of Dr. William Newton Best, of New York City, who was elected a Fellow of the Royal Society of Arts in 1915.

Dr. Best was born in Quincy, Ill., in 1860. He became president and consulting engineer of the well-known firm, W. N. Best Furnace Burner Corporation, Broadway, Manhattan, and owned over 40 patents for inventions for burning oil for heat and in manufacturing plants. Sixty-five per cent. of the furnaces burning oil for refining glass, steel and other metals throughout the United States, are using burners that he invented.

Dr. Best was a member of the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, The American Institute of Metals, and the American Railway Mechanics Association A man of wealth he was a generous supporter of many Brooklyn and other charities.

GENERAL NOTES.

BITUMEN IN PALESTINE.—Bitumen is gathered in Palestine from the Dead Sea, where it is found floating on the surface of the sea. Prior to the war this bitumen was gathered and turned over to an American, who lived in Jerusalem, who in turn exported it by special permit. It is said that the annual export amounted to approximately 50 tons, and that practically the entire output was sent to Germany, where it was used in preparing the gloss for patent leather. At present, writes the United States Assistant Trade Commissioner at Constantinople, very little of this bitumen is being gathered, but it is possible that by using dynamite or other depth charges, large quantities might be obtained out of the Dead Sea.

OIL SHALE IN PALESTINE.—On the shores of the Dead Sea and west of that sea, between Jerusalem and the vicinity of Nebi Musa, is found a peculiar stone. The stone, which is abundant, is commonly used by the local people in making souvenirs. It is a matter of common knowledge, reports the United States Assistant Trade Commissioner at Constantinople, that the Bedouins have used this stone for several years as fuel, and it is reported that during the war it was so used by the Germans. It is said that the latter also extracted oil from it. The stone is called Dead Sea stone and Stinkstein. In the Yarmouk Valley in Northern Palestine are also found vast quantities of an oil-impregnated shale. When burned this shale leaves a very fine quality of lime, which, when air slaked, is said to be very superior for building purposes. It is reported that during the war the Germans extracted oil from this substance by baking.

NEW KNOCKDOWN SAFETY PACKING CASE.—A new knockdown packing case has been placed on the market in Sweden, writes the United States Consul at Gothenburg, which the inventor claims cannot be opened and put together again without detection, as the lock can be protected with a seal which must be broken before the box can be opened in the proper way. The seal is protected by a metal lid, which prevents accidental breakage. It is also stated that the packing case can be taken apart in one or two minutes and can be used over and over again. The case is said to have been patented in 14 countries.

PRODUCTION OF ALSATIAN POTASH.—The production of Alsatian potash during the year 1921, writes the United States Commercial Attaché in Paris, shows a considerable decrease as compared with 1920, as noted by the following figures: Crude salt—1913, 355,341 metric tons; 1918, 333,500 tons; 1919, 591,571 tons; 1920, 1,203,000 tons; 1921, 895,744 tons; pure potash (K2O)—1913, 58,000 metric tons; 1918, 55,700 tons; 1919, 98,000 tons; 1920, 192,480 tons; 1921, 146,355 tons.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY JUNE 26 .. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. R. A. Frazer, "The Oxford Expedition to Spitsbergen, 1921."

British Architects, Royal Institute of, 9, Conduit Street, W., 8.30 p.m. Presentation of Royal Gold Medal.

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Prof. A. W. Porter, "The Law of Distribution of Particles in Colloidal Suspensions, with special reference to Perrin's Investigation." 2. Mr. W. R. Cooper, "The Electro-chemical Effects Produced by Super-imposing Alternating Currents upon Direct Currents." 3. Prof. T. M. Lowry and Mr. E. E. Walker, "Properties of Powders, Part II. Expansion and Shrinkage during Caking of Potassium Carbonate." 4. Prof. T. M. Lowry and Mr. L. P. McHatton, "Properties of Powders, Part III. The Powdering of Minerals by Decrepitation." 5. Dr. A. M. Williams, "Two Properties of Powders." 6. Dr. J. L. Haughton and G. Winifred Ford, "A Note on the Systems in which Metals Crystallise." 7. Mr. A. J. Kieran, "The Electrical Conductivity of Hydrochloric Acid and Potassium Chloride in presence of Sucrose."

British Academy, at the Royal Society, Burlington House, Piccadilly, W., 5 p.m. Mrs. Eugenie Strong, "XVII. Century Sculpture in Italy in its relation to Classical Art."

TUESDAY, JUNE 27 .. Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m.

Anglo-French Society, Scala House, Tottenham Street, W. 6.15 p.m. M. Maurice Thiéry, "Le Théatre de Le Flers et Caillvet."

Anthropological Institute, 50, Great Russell Street, W.C.. 8.15 p.m. Prof. A. Mawer, "The Study of English Place-Names."

WEDNESDAY, JUNE 28 .. Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

THURSDAY, JUNE 29 .. Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Journal of the Royal Society of Arts.

No. 3,632. VOL. LXX.

FRIDAY, JUNE 30, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

ANNUAL GENERAL MEETING.

WEDNESDAY, JUNE 28TH, 1922. MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair. The One-hundred-and-sixty-eighth Annual General Meeting of the Society was held for the purpose of receiving the Council's Report, and the Financial Statement for 1921, and also for the Election of Officers and new Fellows.

A full report of the Meeting will be published in the next issue of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 10TH, 1922.

SIR MARTIN CONWAY, M.A., F.S.A., F.R.G.S., in the Chair.

The paper read was :—

THE DESIGN OF REPEATING PATTERNS FOR DECORATIVE WORK.

By MAJOR PERCY A. MACMAHON, R.A., LL.D., Sc.D., F.R.S.

During the last fifteen months, researches have been in progress concerning the division of flat space into identical figures. These have been undertaken entirely from a scientific point of view, because it became necessary to explore this field of thought in a thorough manner as a preliminary to the study of the corresponding division of space of three dimensions which is required in the treatment of crystallography, crystal structure and the structure of the atom. In scientific work, analogy is a guide which never fails, and it was realised that the experience gained in a comprehensive study of repeating patterns in two dimensions would be of inestimable service in the treatment of the far more difficult questions that arise in the solid theory. Before the investigation commenced, pains were taken to ascertain the present state of knowledge of the subject. On the mathematical side, a search was made among the contributions that have been made from time to time by geometricians. These might have been more important than they have proved to be because the theory of the design is the proper business of the mathematician, and not of anyone in any other walk of life. Similarly, on the side of Art, the current Art text books were consulted, and other literature, including several lectures upon the subject, or very near to the subject, that have been delivered before this Society. Art libraries were requisitioned and yielded much information, and many designs purporting to be faithful copies of ancient and modern decorative work.

The search for the possible shapes of repeating patterns was then commenced, without any particular reference to any application that might be made of results to decorative work, and without any pretence of evolving decorative principles. The object of the work was simply the partition of flat space into identical shaped areas or sets of areas.

One exception may be noted to the above statement. It soon became evident that the mathematical work leads naturally and easily to the special study of patterns which possess some kind of symmetry; and that a calculus can be invented which results in some rules for the construction and classification of symmetrical patterns which may be of special interest to those who, in industry or art, look with favour upon the use of repeating patterns.

Generally speaking, the progress made has resulted in the classification of all

repeating patterns into species, families, genera, etc., just as in the case of botanical specimens.

Repeating patterns have been found to be of service in industry and art throughout the ages, and the object in view in making this communication to the Royal Society of Arts is to bring to the notice of those who are concerned with the practical use of patterns the results that have been arrived at for scientific purposes; because, though possibly they may be found to exert no useful practical influence, yet designers may be at any rate interested in what the mathematicians have been discovering for their own purposes.

In short, the paper is solely concerned with the theory of the shape of the repeating pattern, and has not necessarily any connexion with the way that such patterns may be applied to practical use or to decorative schemes.

As I have explained elsewhere* the scientific principles upon which these patterns can be constructed and classified, I do not propose, in the short time at my disposal, to go into them here in great detail. I intend, after a short preliminary account of the theory, unburdened by the full particulars that are necessary to make the story complete, to shew some of the results upon the screen, and to dwell upon special features that may be new to the audience.

A repeating pattern is understood, in this paper, to be a figure of such a shape that a number of them may be fitted together so as to cover flat space without overlapping, and without leaving interstices.

Any number of separate figures fixed in relative position, which possess the same property, are included in the definition.

The only regular polygons which are repeating patterns are the triangle, the square and the hexagon. These were known to the ancients. Other patterns derived from them have been constructed upon various principles. The Moorish architects were very successful in their use, as is shewn in the decorations of the Alhambra at Grenada, and the Alcazar at Seville. But there has been little co-ordination. The subject is so extensive that this paper deals almost entirely with symmetrical patterns. They can only be satisfactorily studied by taking account of those which are without symmetry, which form the scaffolding of the structure, and, finally, disappear. The method of study will now be introduced by the consideration of the simplest repeat, the equilateral triangle. This form differs from the square and the hexagon in one important respect. When we assemble the triangles, side by side, we find that they appear necessarily in two orientations or aspects. This is not the case with either the square or the hexagon, which, when assembled, present only one aspect. The bearing of this remark will appear later.

We commence by dividing the triangle into three equal parts by lines joining its centre with the angular points.

We now number the compartments of the triangle 1, 2, 3, always in counter clock wise order, and for convenience regard these numbers as denoting three different colours. The triangles, being coloured in the same manner, have still the fundamental property of being identical. We now propose to assemble these triangles in such wise that a certain law of contact of colours between adjacent compartments is in evidence. The most obvious law is that which insists that adjacent compartments shall be similarly coloured. Such an assemblage is shewn in Fig. 1, and it is clear that the construction can be extended indefinitely. The diagram establishes that the coloured triangle is a repeating pattern, and, moreover, one of a new kind because the assemblage is subject to a particular condition of colour contact. This contact, in respect of the triangular base, we call the First Contact System.

We may now denote it by 1 to 1, 2 to 2, 3 to 3, or, shortly, by 11, 22, 33.

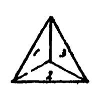
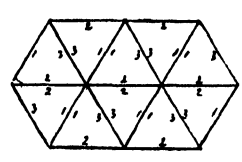


Fig. 1.



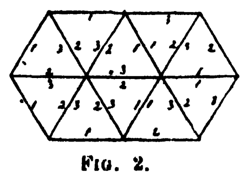


Fig. 2.

* Proc. R.S. 1922.

In the case of the triangular base one other Contact System is possible, because we may take as the condition of assemblage, that one compartment, say that coloured 1, shall be adjacent to a compartment also coloured 1, while a compartment coloured 2 shall be adjacent to one coloured 3.

This is the contact system 1 to 1, 2 to 3, or shortly 11, 23. The assemblage, subject to this condition, is established by fig. 2, which can be indefinitely extended.

This system again gives us a new repeating pattern. Looking at both contact systems, we notice that the colour contacts are of only two natures. Adjacent compartments are either similarly or differently coloured. In each of the two cases the "repeat" is an equilateral triangle involving three colours. We now seek to transform the triangle, by connecting colour with shape, into a piece of another shape which is uncoloured. Consider the compartments coloured 1. The external boundary of each is a straight line which joins two angular points. How can we alter this boundary so that it will still fit into the similarly altered boundary of another compartment coloured 1? If we can do this it is clear that we can get rid of the colour and rely upon the altered shape of boundary to determine mechanically and automatically the same condition of assemblage as arises from the contact system affecting the colour 1.

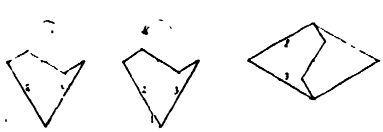


Fig. 3.

Fig. 3 shews a simple way of effecting this transformation. A certain zig-gag boundary of the compartment leaves each triangle of the same shape and they fit together automatically. It is seen that the new boundary is constructed by adding and subtracting a certain area from the triangle and that the contours which determine the added and subtracted positions are in point symmetry with regard to the mid-point of the original straight line boundary between the compartments. In other words, each contour is the point-image of the other with respect to the said mid-point. The practical result of the construction is that the new boundary between the points A, B, is unchanged by rotation through two right-angles about the mid-point of AB.

This is exactly what is wanted so as to ensure that the triangles may be altered in the same manner, and fit together. In general we effect the transformation from colour to shape by taking any system of closed contours exterior to the original boundary as determining portions to be added to the triangle and a corresponding system of closed contours inside the boundary as determining portions to be subtracted from the triangle; the condition being that the latter system of contours must be the point-image of the former system with respect to the mid-point of the original boundary. The new shape or pattern then effectively replaces the colour. Subject to certain conditions in regard to the areas within which these systems of contour may be drawn, so that they may be compatible with other transformations connected with other colours, the designer has a free hand, and is in no way restricted to the use of drawing instruments. Examples of transformations of this kind are shewn upon the screen.

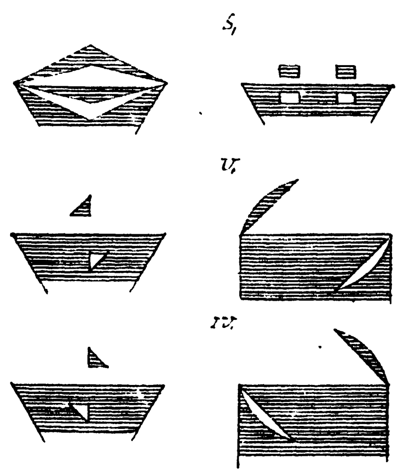


Fig. 4.

They are of two different types. One which is symmetrical about the straight line perpendicular to the original boundary at its mid-point is said to be of type s_1. One which is unsymmetrical about the same line is of type v_1. Here the suffix has reference to the first nature of contact between colours. A transformation which is the optical reflection of a v_1, in a line perpendicular, to the original boundary, though one extremity is denoted by iv_1, a notation which is of much service when the design of symmetrical patterns is in

view. In order to avoid mutual interference of transformation patterns, we will for the present regard such patterns as restricted to lie within the rhombus found by the coloured compartment and its reflexion in the boundary. It will be found later that under certain circumstances this restriction may be much modified.

When we are dealing with the First System of Contact, each coloured compartment is separately transformed upon the principle above set forth with the result that we obtain a repeating pattern which replaces the coloured triangle. It will be observed that, following the rules of construction, these repeating shapes can be obtained in infinite variety. When the three colours differ from one another three different transformations enter into the construction of the pattern. If the colours described by 2, 3, be identical (so that for 3 we write 2) and different from the colour 1, two different transformations will enter; while if the three colours be alike (so that we write 1 for both 2 and 3) only one transformation enters and is applied to each of the three compartments. We have therefore the three cases, examples of which are shewn upon the screen. We have here the first part of a classification.

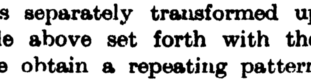


FIG. 5

It will be observed that the repeating patterns, obtainable by transformation from the triangular base, are broadly speaking of three natures. Some are continuous within a single boundary line or contour. Others are discontinuous within a single external contour, differing from those which are continuous by exhibiting gaps or windows within the contour. Others consist of two or more separate figures relatively fixed in position. These it is convenient to term block, stencil and archipelago repeating patterns respectively. It will be observed too that some patterns partake of both stencil and archipelago characters.

The three natures specified occur in the case of all bases and all categories belonging to them.

We pass now to the Second Contact System 1 to 1, 2 to 3, which involves a contact of the second nature, because 2 to 3 specifies a contact between different colours.

If we make any new pattern or shape to replace the colour 2 the new pattern to replace the colour 3 is thereby determined because the two pieces have to fit into one another. We have to find the geometrical relation between the two patterns.

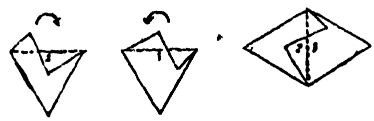


FIG. 6.

In the diagram, Fig. 6, the colour 2 is replaced by an unsymmetrical zig-zag shape and this determines a corresponding but different zigzag shape to replace the colour 3 in order that the two pieces may fit together when rotated in the direction of the arrows. This fitting necessitates the part added to the piece in the case of the colour 2 being the point image of the part subtracted from the piece in the case of the colour 3 and the part subtracted in the case of the colour 2 being the point image of the part added for the colour 3. To carry this out we suppose the triangles superposed and the images taken with respect to the mid-point of the original boundary.

We generalise this theory by taking, to replace the colour 2, any system of closed contours to determine additions and any system to determine subtractions from the piece; and then, to replace the colour 3, we take systems of contours the point images of the former as above explained. Patterns of infinite variety, subject to conditions that may present themselves, may thus be drawn and effectively replace the colours. Examples of transformations of this nature are shown upon the screen—Fig. 7.

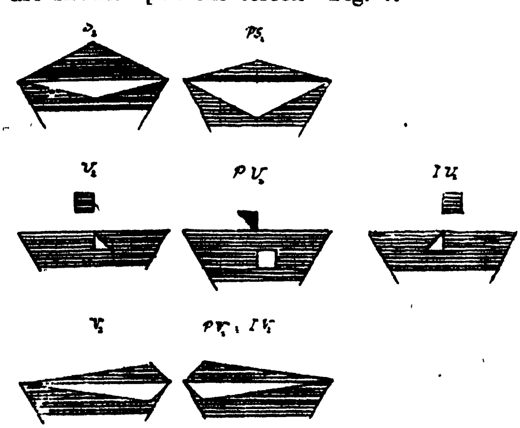


FIG. 7.

For the purpose of a symmetrical calculus they are separable into three types.

One which is symmetrical about a straight line perpendicular to the original boundary through its mid-point is said to be of type S_2, the suffix 2 having reference to the second nature of contact. If this refer to the colour 2, that for the colour 3 is denoted by PS_2.

One which is unsymmetrical about the straight line above specified and is also unsymmetrical, as regards contours, about the original boundary itself is said to be of type U_2, while the corresponding transformation for the other colour is denoted by PU_2.

One which is *only* symmetrical as regards its contours about the original boundary line is said to be of type V_2, and that for the other colour is denoted by PV_2.

We have also a pattern IV_2.

It will be noticed that

PV_2 is equivalent to IV_2,

a circumstance of great importance to the symmetrical calculus.

We have only one species of pattern, as shown in Fig. 8,

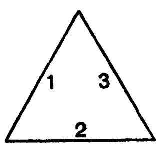


FIG. 8

the colours 2, 3 being transformed as above and the colour 1 by any transformation which appertains to the first nature of contact.

Repeating patterns based upon the equilateral triangle may be symmetrical about a line in the plane which bisects one of the angles. To secure symmetry we take transformation patterns for the sides containing the angles, one of which is the reflexion of the other. These patterns may be S_1 and S_1, or U_1 and IU_1 when the compartments to be transformed are of the same colour, and V_2 and PV_2 ($=IV_2$) when the compartments are of different colours. A second kind of symmetry is about an axis perpendicular to the plane through the centre of the triangle. The symmetry is then triangular and can be secured in only one way, viz., by transforming each compartment according to the same pattern. This is only possible when the three compartments are of the same colour. In the subjoined classification (Fig. 9) the letters T.E. stand for Triangle Equilateral. The numbers (i), (ii) have reference to the contact system which governs the assemblage and the transformations. The letters a, b, c, . . . refer to the particular colour scheme of the compartments.

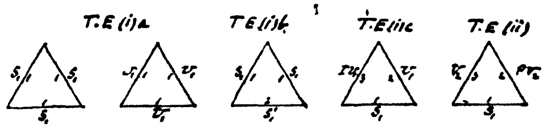
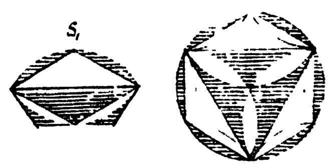


FIG. 9.

We have thus five categories of symmetrical repeats, some examples of which are thrown upon the screen. Each category involves an infinite number of repeats. Other bases are treated in a similar manner. Such include the isosceles triangles whose vertical angles are 90° and 120°, the square, rectangle, parallelogram and rhombus; the regular hexagon and some special hexagons and a special pentagon. These have been found particularly suitable and practically certain to include all repeats that are likely to be met with or to be of practical service. The details of these various species, though they have been worked out, cannot be given here, and I must content myself with showing some typical results later in the evening.

An interesting stencil repeat, based upon the triangle, which has a circular external boundary is now illustrated.



T.E. (i) a.

FIG. 10.

It is the result of applying the S_1 transformation (shown by its side) to each of three compartments of the triangle. It will be noticed that the transformation is not restricted to lie within the rhombus, to which reference has been made, but still there is no interference or incompatibility.

Circular repeats can be constructed in an infinite number of ways. Another is illustrated in which the triangle base has entirely disappeared as a result of the

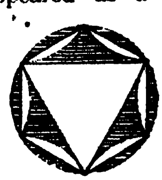


FIG. 11.

transformation applied to each side. The reader will have no difficulty in discovering the S_1 transformation that has been employed.

All repeats based upon the equilateral triangle must exhibit when assembled either two or six aspects. One category (that to which the helmet pattern which has been shown belongs) can always be assembled in two distinct ways so as to show either two or six aspects at pleasure.

The transformation that has been explained is in principle applicable to all bases. It may be regarded as a line-transformation, because the point-image process takes place with respect to the mid-point of the boundary line of the compartment. There is another transformation which may be termed a point-transformation, because the point image process takes place with respect to an angular point of the base. In this case, the division of the base is not by lines radiating from the centre to the angular points, but by lines drawn from the centre perpendicular to the sides. The resulting transformations are co-extensive with those which have been studied, and lead to a corresponding symmetrical calculus. They are chiefly of theoretical interest, and have been developed elsewhere. Since they lead invariably to archipelago repeats, or, at most, to those of a peninsular nature, they would not be of great interest to those engaged in practical applications. An exception must be made to this statement in the case of certain combinations of point and line transformations, but this feature cannot be taken up on the present occasion. Speaking generally we are not bound down to the particular division of the triangle (or other base) that has been employed to determine compartments. Any division of the triangle into three parts can be taken as determining the regions within which the transformation patterns may be drawn.

While shewing upon the screen a selection of designs of repeating patterns that result from the principles that have been set forth, I draw attention to some special points of interest.

COMPLEMENTARY REPEATING PATTERNS.

It is possible, in general, to draw a contour surrounding any pattern, which has the property that the area inside the contour which is not part of the area of the pattern is itself a repeating pattern. The two patterns may be termed "complementary" in regard to the external contour.

In general, this external contour can be drawn in an unlimited number of ways.

Under certain conditions which can be specified, the external contour has the property that the whole area which it includes is a repeating pattern.

Thus, when the base is an equilateral triangle, we take O for the centre of the triangle, join it to the vertices and reflect the compartments OBC, OCA, OAB, in the sides, BC, CA, HB respectively producing the external regular hexagon. We can now draw the transformation patterns within the figure OD, OE, OF, each of which is a rhombus.

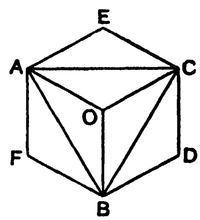


FIG. 12

Taking in particular the rhombus OE the pattern, for the first nature of contact, consists of any system of closed contours within the triangle ACE and then a system, point images of these with respect to the mid-point of AC, within the triangle AOC. We note that the triangle AOC is the point-image of AEC, so that those areas of triangles AEC, AOC, which are not included within the said closed contours, must also be in point-image relation and therefore give a complementary transformation pattern. If we take these complementary transformations in the case of each compartment of the base, we are led to a complementary repeating pattern.

The two repeats are complementary with respect to the external hexagon, and since the latter is determined by a particular division of the base into three parts, we are equally justified in saying that they are complementary in respect of a dissection of the base triangle into three parts. The fact is that any dissection of the base may be taken to determine transformation areas, an external contour and pairs of repeating patterns. Similar considerations apply when the transformation appertains to the second nature of contact, and it is thence established that the principle of complementary repeats is of universal application.

Every Quadrilateral Figure is a Repeating Pattern.

This important fact came to light at an early stage of the investigation. A search in mathematical literature revealed that this was known for figures restricted to be convex, but that, apparently, it had not been realised that it was also true when the figure possesses a re-entering angle. The proof is very simple, and may be made to depend upon the circumstance that the sum of the interior angles is equal to four right angles. It may appear, ultimately, that the complete theorem has been previously stated, but there is no doubt whatever that it has not been realised in circles likely to be well informed. A parquet floor can be constructed with four sided blocks of any shape, and a curious result follows. If it were the intention to use rectangular blocks, and by a mistake in setting the circular saw (or otherwise), each block were slightly different (but by the same amount) from the rectangular found, it would not be necessary to scrap them all; the floor can still be laid without any difficulty.

In assemblage the four-sided figure always presents two aspects. If two such figures, the four sides being of unequal lengths, be assembled, two sides of equal lengths must be in contact and the resulting figure is a hexagon which has each pair of opposite sides equal and parallel. This hexagon is a well known repeating pattern. However, it has been recently shown that it is only *necessary* for a hexagon to have one pair of opposite sides equal and parallel for it to possess the repeating property.

An Equilateral Pentagon Repeating Pattern.

A regular pentagon, which has equal angles as well as equal sides, is not a repeating pattern. There is a certain degree of misconception in this matter, arising from the circumstance that a regular pentagon frequently appears in repeating pattern designs. In such cases, it is invariably accompanied by some other figure or figures so that the combination is a repeating pattern. It will be shewn later that a figure which does not repeat, can always be added to so as to convert it into one which possesses the desired property.

There are several equilateral pentagons of the required nature, but there is one which is more nearly regular than the others, and which can be constructed in the following manner :—

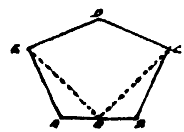


Fig. 13.

From the middle point O of AB draw OC, OE, making angles of 45° with AB. Make BC and AE equal to AB and the angles BCD, AED right angles. ABCDE is the repeating pentagon which can be derived by transformation from a square base. A tessellation of these is shewn, whence it appears that the assemblage exhibits four aspects, and that it can be derived from two similar systems of hexagons at right angles to one another. The intersections of the systems shew each hexagon of both systems to be composed of four of the pentagons of different aspects.

This pentagon can be used as a base for transformation. An example of a repeat derived from it and the assemblage, is thrown upon the screen.

If a particular repeat gives a satisfactory result when it is assembled, a repeat complementary to it may be assembled with a fair prospect of success. The assemblage complementary to the one shewn in respect of one of the simplest external contours that can be drawn, is of the same general character and quite interesting. The point has not, however, been tested to any great extent.

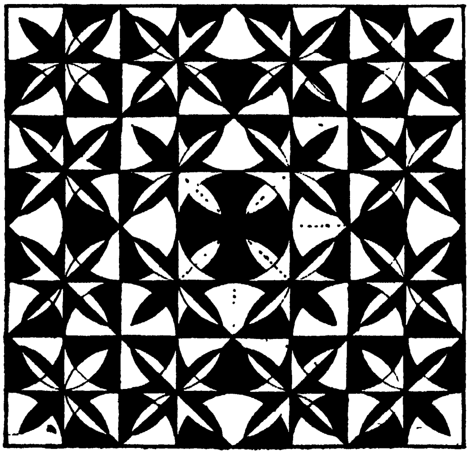
The transformation of the square base presents some novel features. When the compartments are determined by the diagonals it yields no fewer than 27 types of repeats, each of which includes an infinite number of examples. The assemblage must exhibit either one, two or four aspects and one category, specimens of which have been shown, can be assembled so as to exhibit either one, two or four aspects. The property of a repeat in regard to aspects is an important help in the classification. It will have been observed, in the case of the equilateral triangle base when the compartments are determined by lines joining the centre to the angular points, that the reflexion of the compartments in the sides produces an external boundary which is a regular hexagon. When the base is a square the same geometrical construction produces

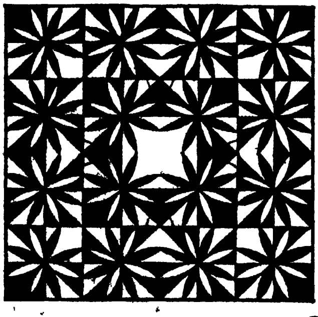
an external square of twice the area of the base and differing in orientation by 45°. This circumstance that the square figure again appears leads to interesting results. If any repeating pattern be constructed upon the square base, the transformation pattern being restricted to lie within the area formed by the compartment and its reflexion there exists a *repeating geometrical process*, which results, each time it is carried out, in a square of double the area, within which are two complementary repeating patterns. These can be evolved any number of times at pleasure, and the process always leaves the original repeat as the central feature. The process is, in fact, effective in producing at once an expansion and a centralization of the repeat. To obtain the most interesting patterns the chosen repeat should have quadrangular symmetry. Any design, possessing for choice the symmetry mentioned, may be chosen, although it is not a repeat, and the results of the first application of the process is to convert it into a repeat and then the construction may proceed as before. A number of these centralizations are shown upon the screen (Plate 1). They are possibly the most complicated repeating patterns that have ever been constructed. Notwithstanding this they are interesting and deserving of close examination.

The rectangle and the parallelogram can be similarly but less effectively treated.

It will be noted that here the design is dependent essentially upon a repeating process and not upon the assembling of a repeating pattern.

From the above we are naturally led to consider the general question of converting a pattern which does not repeat into a repeating pattern. Examples have already been given in the case of the Maltese Cross, the Victoria Cross and the Grand Cross of the Bath and of some other patterns.





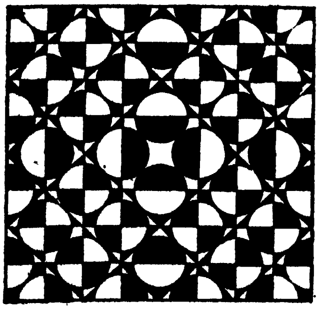


PLATE I.

Centralised Repeating Patterns.

Of the crosses commonly met with, the Greek Cross, composed of five squares and the Latin Cross composed of six squares are already repeats. In the case of other equal and unequal armed crosses, we may proceed in more than one way in order to effect the conversion. We may circumscribe a square or rectangle and making use of the principle of transformation convert the cross into a stencil repeat of which it is the central feature *or* we use the same principle to make some small alteration in the shape which will cause it to possess the repeating property. Some examples are illustrated.

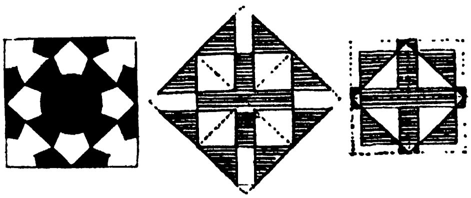


FIG. 14.

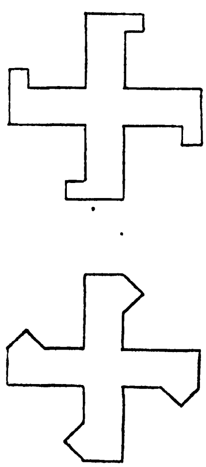


FIG. 15.

When a wall or other flat surface is decorated by means of floral or other designs equally spaced, it may not be immediately evident that we are in the presence of a repeating pattern, as it has been defined at the commencement of the paper. That this is so, as regards the external contour of the design, is shown by the accompanying diagram (Fig. 16). The design is shown, diagrammatically, placed at the centre of each cell of a square tessellation. The repeating pattern is then seen to be the archipelago and stencil combination denoted by the shaded areas. All such decorations can, therefore, be duly entered in their proper places in the classification.

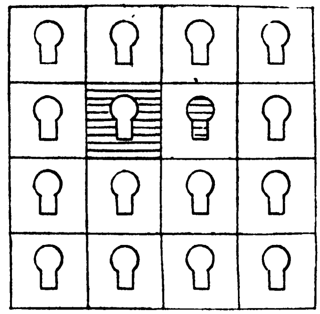


FIG. 16.

The question of aspects assumes increased importance when we come to the study of the transformations on the regular hexagonal base. In this case there are three general systems of contact and one of these has the property that all the derived repeats, infinite in number, are exhibited in three aspects when assembled. This is remarkable because a diligent search has not resulted in discovering, in ancient or modern work, any assemblage with this number of aspects. The reason why three aspects present themselves is that three is a divisor of six, while the hexagon itself can be assembled so as to show only one aspect. The number three does not appear when the regular triangle is the base, because, since the triangle itself shows when assembled two aspects, the derived repeats must show a number of aspects which is a multiple of two. It does not appear when the base is any quadrilateral, because three is not a divisor of four.

Examples of these repeats and an assemblage are shown upon the screen (Plate II.)

Some hundreds of categories of repeats are derived from the regular and some special hexagons by the transformations. A few of these are exhibited (Plates III., IV.)

In conclusion, it may be stated that there are many other principles available for the study of this subject.

There is the principle of dissection arising from the circumstance that if any repeat can be dissected into a number of identical figures, such figure is necessarily a repeat.

The principle of "composition" which appears because in an assemblage of repeats it is possible to draw around a certain number a boundary which encloses a repeat composed of a number of identical repeats.

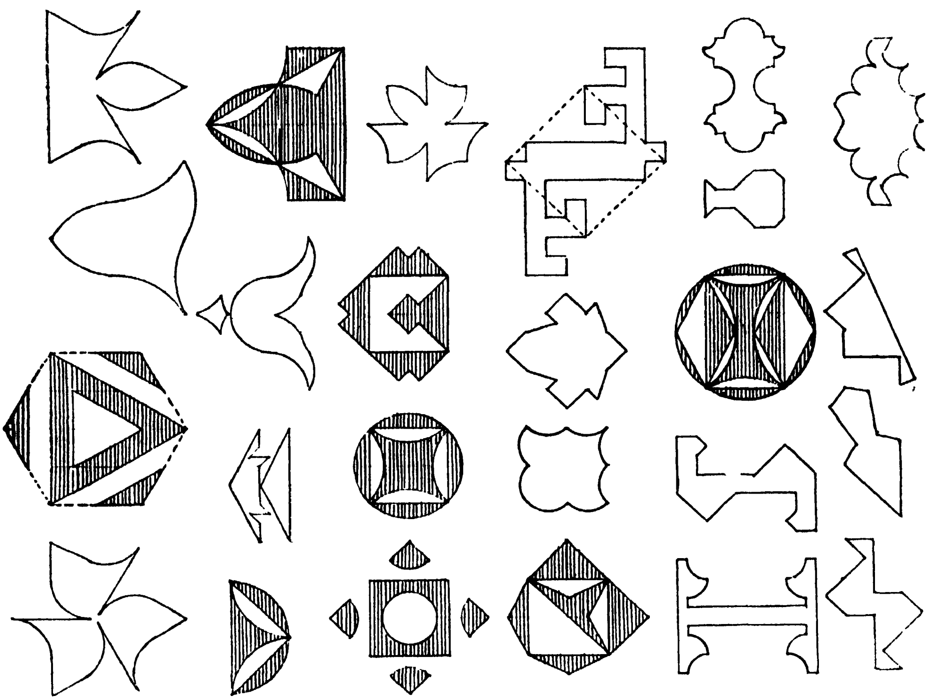


PLATE III.
Repeating Patterns designed from triangular and quadrangular bases.

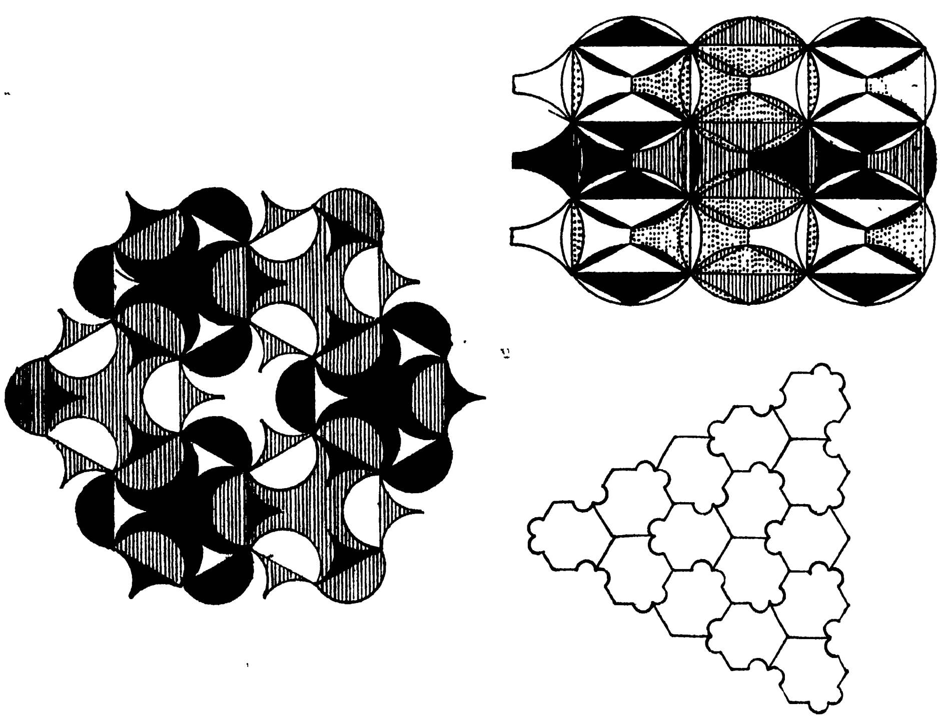


PLATE II.
Some Assemblages of Repeating Patterns.

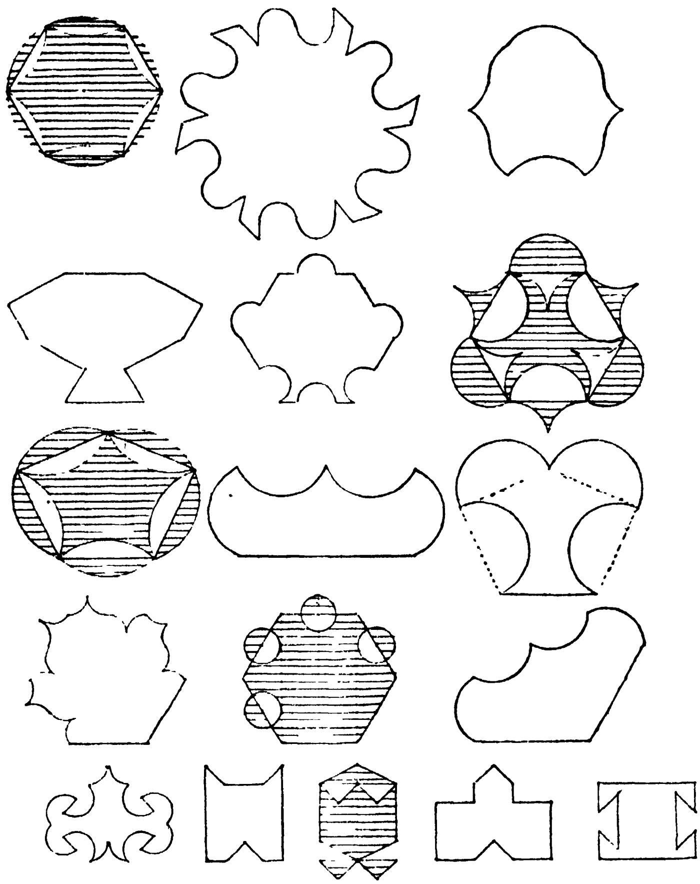


PLATE IV.

Repeating Patterns derived from hexagonal and pentagonal bases.

The principle of "absorption" which presents itself because, in an assemblage, certain selected figures can be made to absorb portions of neighbouring figures and so fill up the space as required.

The principle of "translation," which was enunciated by Lord Kelvin in connection with the homogenous partitioning of space of three dimensions.

The principle of "continuous growth" of equal and similar and similarly oriented contours placed at points which are uniformly distributed.

The principle of taking large ruled and cross-ruled areas covered with long lines straight or waved (to use the vernacular of some of the art text books) according to definite laws, when the spaces between such lines are seen to be repeating patterns.

All of these methods were examined, but they were found to be inferior for the purposes of design and classification and thorough exploration of the field, to the principle of transformation adopted in this research. This principle appears to be new to the subject. In its general uses the other principles should be constantly borne in mind and will be found to be useful auxiliaries.

The connection of the principle of transformation with the last-named principle of long straight or waved lines may suitably be the subject of some observations. When any repeating pattern is assembled so as to cover a definite area it is always possible to draw through it systems of long lines, straight or waved, which are seen by their intersections to produce the patterns.

Conversely we may design, in a variety of ways, these systems of long lines and thus produce the patterns, which, of course, cannot be either of the stencil or archipelago types.

It follows that this principle, if carried out to the fullest extent, can only deal with about 20 per cent. of the ground to be explored. Now the principle of transformation deals with assemblages of the simplest repeating patterns and the transformations of the compartment boundaries effectively transform all the long lines that can be observed passing through the assemblage. It transforms them in every possible manner into other long lines passing through assemblages of other repeats; but not only so, it also so transforms them that they cease to be long lines straight or wavy, and the repeats that existed initially are turned into stencil or archipelago repeats or combinations of these. It follows that the principle not only does, what the long line principle can do, in a far more thorough manner, but it also deals with the remaining 80 per cent. of the ground that that principle, as it exists to-day, cannot touch. Repeating patterns have been recently sent to me from China, Japan, Peru, India. Egypt and many other parts of the world, but I have never failed to place any specimen in its proper place in the classification that had been previously constructed. This encourages me to hope that the classification suffices for all practical purposes.

I may add that at least 90 per cent. of the few hundreds of categories have apparently never been drawn upon for practical application.

DISCUSSION.

THE CHAIRMAN said that he was sure the paper had kept the attention of members of the audience fully on the stretch, and if they had followed every convolution as Major MacMahon had developed it, they had undergone a very strenuous intellectual exercise. He confessed that here and there he would like to read passages in the paper over again at leisure and consider them with more time at his disposal. But what had struck him, amongst other things, was the number of ancient and early decorators of all ages and periods who had felt their way towards, at all events, the simpler forms of this repeating pattern. His impression was that there was a repeating pattern of the curvilinear sort on an ancient Minoan pot discovered by Sir Arthur Evans, in Crete. All architectural design constantly employed simple forms of these repeating patterns. How far it would be wise from the aesthetic point of view to carry the elaboration of such patterns he would not attempt at the moment to suggest. It was conceivable that too great an elaboration might defeat the object of the repetition which aesthetically had the purpose rather of being restful than agitative. Some of the designs which Major MacMahon had elaborated certainly seemed to him to possess artistic possibilities. Did he understand him correctly to say that there was no real instance of repeating patterns produced from circles?

MAJOR MACMAHON stated that he had not found any.

THE CHAIRMAN: Yet we had surfaces entirely filled with those intersecting circles repeating over and over again.

(The Chairman here demonstrated on the blackboard the kind of form he had in mind in suggesting that repeating patterns might be produced from circles). He added that this pattern was common in late Roman times and in early Coptic art. It came over to the west along with early Gothic goldsmithry in the fourth and fifth centuries, and appeared in England in the seventh century, and was, he supposed, the commonest repeating pattern in barbarian Anglo-Saxon art.

SIR FRANCIS PIGGOTT, whose remarks were illustrated by a number of lantern slides, said he rejoiced that so eminent a mathematician as Major MacMahon should have turned from the austerities of his favourite subject and found recreation in decorative design; because he had always believed that there were mysterious links at present undiscovered between science and art. But he was diffident of talking on the subject, because his scientific knowledge was of the scantiest, and he begged indulgence for any slips he might make. He would not like what he was going to say to be regarded as criticism of the very learned paper they had listened to; he would rather put it forward as a view which had gradually been shaping itself in his mind during a long period of study of decorative design. It was a view which differed almost at all points from that elaborated by Major MacMahon, though it would not be the first time that the same result had been reached by different paths. First: his cardinal principle was that design, like everything else, was subject to a law of natural evolution, and that the most complicated designs could be traced back to some early form. It was not always easy to discover the intermediate stages of development; but in two cases, as he showed in a paper read before the Society in July, 1919, he had actually discovered examples of practically all the progressive stages of development of two very different schemes of design in the Japanese temples. These were (*a*) the elaborate diaper known familiarly as the "Cloisonné pattern," and (*b*) the equally elaborate traceries of the lattices. Secondly: believing as he did in natural evolution, it followed that he rebelled at the idea of "assembling" a series of repeated

designs. The two ideas were antagonistic. "Assembling" implied starting with the design, and working backwards instead of forwards. And it had this peril, that if the principle on which the design was based was not accurately appreciated, the repeats would not work properly; the completed tesselation would be full of flaws. As an example and a warning, he might refer to what was commonly called the "Greek Key Pattern." The Greeks borrowed it from the East, but knowing nothing of its evolution from the Cloisonné diaper, produced some variants which were merely artistic monstrosities, formless and void. The "Key" border or fret was a section cut transversely to the structure of the diaper; and he noted here that this diaper was the only case he could call to mind of an Eastern design which was "assembled," its component parts being limbs of the Pakwa symbol. Thirdly: He did not accept the equilateral triangle as a true repeating unit, because it involved the introduction of the "inverted repeat" out of due time. Inversion of the unit of design came later in the stages of evolution. He thought the rhombus, of which the triangle was the half, was the true repeat.

These things said, he would now endeavour to explain what he thought was the gradual evolution of repeated design. One class of natural forms was the result of forces constant in their action. By "form" he meant a space enclosed by one or more lines; which was sufficiently accurate for the purpose in hand, though it would exclude the catenary, the spiral, and the whorl, which were properly described as "forms," and which were natural forms. If we took a point from which force was constantly radiating in all directions, and it was cut by a line equidistant in its entire length from the point of force, we got in two dimensions the circle; if it was cut by a curved plane we got, in three dimensions, the sphere. He thought this was the first natural form; and it had, possibly from this cause, always had a sacred or mystic significance in the East. The most beautiful designs were contained in a circle, the detail radiating tangentially and internally from the circumference. The division of the circle into two equal parts by opposed tangential semi-circles on the two halves of the diameter was the Eastern symbol of completeness, the Yang and the Ying, the symbolic representation of the positive and the negative, the one complementary to the other. Again, if we took a series of points of force, all of them equidistant from one another (arranged, that is, on the points of a series of equilateral triangles) then the forces, radiating as before constantly and equally in all directions, when they met, would annihilate one another, and the various lines of meeting form a series or "repeat" of hexagons; and he thought this was the second natural form. The bees, packed closely to one another in their hive, were points of force, and they formed the honeycomb, which was the natural demonstration of this law. The hexagon too, was the law of the snow crystal. He imagined that if the expansion were in three dimensions there would result a sphere with flattened hexagonal surfaces. It was interesting to note that the Lattice Fungus was a sphere with flattened pentagonal shapes, more or less regular. The conic sections and the cardioid were also natural forms, but they were independent of forces in their construction. Now human agency came into play, and we found man assisting in the evolution of form, though not at first deliberately. He filled in the light and air cavities in the walls of his house with laths, from which repeated forms resulted--the square, the rectangle, and the lozenge. Here we had forms repeated which after having served for use became groundworks of ornamentation: which sometimes depended merely on the simple forms repeated, or they were filled with designs shaped to the forms which were themselves repeated simply or with variations.

The intersecting lath had been a very important factor in the evolution of repeated design, for the large family of lattices depended on it; and this brought him to the last of his differences with the author. He said, and truly, that "When any repeating pattern is assembled so as to cover a definite area, it is always possible to draw through it systems of long lines straight or waved, which are seen by their intersections to produce the patterns. Conversely, we may design, in a variety of ways, these systems of long lines and thus produce the patterns." But having lived among them for many years, and having imbibed the spirit of the workers and their work, he (the speaker) could come to no other conclusion than that the "long line," or the lath, was the fount and origin of repeated rectangular design. Some of the lattices were painfully intricate, and he doubted, with the utmost deference, whether it would be possible to design the resulting forms without the lath, much less assemble them.

The speaker then showed what he described as the most complicated lattice he knew, and it depended entirely on the series of intersecting laths, with a kink in the middle, which had given it its name the "Lightning Lattice." The laths themselves gave an interesting pattern and the light space was also a repeating figure which was well-known in Japanese heraldry. As he had said once before, if an architect wanted to devise a punishment for a refractory pupil, he should set him to work to draw it. And he would conclude his remarks with this question to Major MacMahon: Given these repeating figures, could he really assemble them? He noted that Major MacMahon defined a "repeat" as one which, when the identical

figures were assembled, filled a given space of two dimensions "without leaving any interstices"; but the special feature of Japanese repeated design was that there were interstices, and that these were themselves the elements of a repeated design, which sometimes was the primary, and sometimes the secondary, characteristic of the whole composition.

Sir Hercules Read, LL.D., F.B.A., said that he was not at all prepared to enter the arena on the strictly scientific side that, very naturally, Major MacMahon had taken up. His experience in patterns of this sort was entirely from the empirical side, and in that respect he would much have preferred to cross swords for a moment with the last speaker, whose remarks showed him to have been convinced by certain widely spread heresies. However, it would not be fair to discuss a discussion, and so he would say a few words in relation to the paper itself. He had talked with Major MacMahon a year or more ago on this subject, and had shown him then a certain number of handsomely illustrated books containing a great variety of repeated designs, which he (Major MacMahon) looked at with very considerable interest. The greater number of these were of Moorish construction. Major MacMahon had said nothing at all, perhaps wisely and cautiously, about whether or no the Moors who constructed these superficial designs for their buildings worked by rule of thumb, or had behind them some such principle as he had laid before the Society that evening. He thought that was rather an interesting side to the investigation, because, as he was sure nobody knew better than Major MacMahon himself, there were no greater mathematicians in the early Middle Ages than the Moors and the Arabs, to whom were owing those very charming designs seen in the Alhambra and other great buildings erected in Spain and elsewhere. They were obliged to use this particular form of decoration, because their very rigid creed forbade them to use living forms; therefore, they adopted the conventions which Major MacMahon had shown so well that evening for decorating the walls of their buildings. But these Moorish designs were so various, and, he thought, almost invariably so beautiful, as well as so unusually accurate, that it seemed to him almost inconceivable that there should not have been behind them some such principle as Major MacMahon had laid down. Whether there was any evidence for or against it, he was quite unaware; but when one had a nation of mathematicians building with patterns of this sort, there was a *prima facie* case for believing that they pursued their construction on given principles. One other point he might mention—and here he thought Major MacMahon did make a definite statement concerning the Chinese. The author had suggested that because the Chinese only used one particular form of interlocking arrangement, therefore they were not possessed of any knowledge of principle, otherwise they would have used more. That, he thought, supposed a greater love of variety in ornamental forms than was found among the Chinese. The speaker was fairly familiar with Chinese works of art, from the very earliest times up to their products of the day before yesterday, and the one thing to be discovered was uniformity and monotony of design, where a greater variety would have been infinitely more pleasing, at any rate to our eyes. His argument was that, because one only found this one special form of ornamental repeating design, it was not a safe deduction to suppose that the Chinese were not aware of any underlying principle. There, again, one had to deal with a race of the highest intellect, and it seemed to him not unlikely from his knowledge of them and their ways, that they also were likely to have been possessed of the principle underlying all this repeating pattern business.

Sir Francis Piggott had alluded to the greater charm that in his eyes—and in the speaker's also, for that matter—came from what might be called the evolution of the natural process from one design to another, and had said that the designs produced by such evolutionary methods were more agreeable than those which Major MacMahon had put on the screen, and which were founded on a strictly scientific principle carried out with the greatest possible care. In that respect, it seemed to him (the speaker), that they could hardly be agreed or judicial on such a point. The matter was as yet in its infancy, and here, again, he was sure that the lecturer would agree with him that there were infinite possibilities in patterns which might be more pleasing to the artistic eye than those which, in the elementary stages of carrying out his principle, he had shown as illustrations that evening. There was a certain aridity about the design of the latter, a want of artistic freedom, a lack of charm in line and contour, which was probably not due to the method whereby they were produced, but only to the fact that the method was quite novel to them. He must compliment Major MacMahon upon having given the Society, without question, one of the most ingenious solutions of many of these problems of which he had ever heard. The speaker had been intensely interested from beginning to end.

Dr. E. H. Hankin said with regard to the suggestion that Moorish artists employed methods of design similar to that now developed with so much ingenuity by Major MacMahon, a reference might be made to a paper that he had read before the Society in 1905 that dealt with some discoveries of methods of design

in Saracenic art.* A further and more detailed description of these patterns was about to be published in the Memoirs of the Archæological Department of the Government of India. Nothing would be found in this description that recalled in any way the discoveries of Major MacMahon. A reason why his work was welcome was that there was a constant need for the discovery of new geometrical patterns. These patterns rapidly became monotonous by repetition. The standard aimed at, and generally achieved, in Saracenic art was that no two panels or decorated spaces in a building should have the same pattern. This urgent need for novelty inevitably led to complexity. At length at the highest development of this art, its patterns showed monotony in their complexity. Their complexity was far beyond what the ordinary onlooker could appreciate. As the proverb said, there was no accounting for tastes. Whether a particular pattern was pleasing or not depended on qualities that for the most part could not be estimated or valued by conscious reason. We had had examples of this fact to-night. Nearly all of the simpler patterns shown by Major MacMahon, however they might have appealed to us intellectually, had no kind of æsthetic value. It was only the more complicated of his patterns shown at the end of the lecture that were pleasing to our artistic sense. Their greater complexity could only be a part reason for the difference, for in Saracenic art we often found patterns of great simplicity but yet of comparatively high æsthetic value. A feature in which Major MacMahon's patterns seemed to be inferior to those of Saracenic art was that in the latter the different pattern outlines were usually interdependent. A line that limited one side of a pattern space on being followed was found, for instance, to be part of an octagon, while the line limiting the other side of the same space was part of another octagon. Or, in the more complicated of these patterns, every line was seen to run a zig-zag course right through the pattern from one side to the other. No line came to a dead end. Each line after bounding one pattern space was continued to assist in bounding other pattern spaces. Generally, if necessary, the lines could be drawn interlaced, passing alternately over and under all the other lines of the pattern that they met. With Major MacMahon's patterns, on the contrary, there were numerous dead ends. Each line enclosed its own pattern space and took no part in forming boundaries of neighbouring spaces, except of course in so far as one space was conterminous with its neighbours. Owing to this character these patterns seemed more fitted for mosaic pavements, for instance, which were made up of separate pieces than for decoration of panels, dadoes or friezes where a continued pattern seemed more appropriate. These considerations indicated the direction in which some practical use might be found for Major MacMahon's very ingenious and striking researches.

THE CHAIRMAN said that the Society would desire to return its hearty thanks to Major MacMahon for his delightful and ingenious address. What he had told them had been obviously the result of an enormous amount of work, and the Society must reckon itself fortunate to have heard from him the results at which he had arrived

The vote of thanks was accorded unanimously.

MAJOR MACMAHON, after thanking the Chairman and the Society, replied to some of the points raised in the discussion. With reference to what the Chairman had said about the circular pattern which he had drawn on the bleakboard, that was not properly a repeating pattern until certain other lines were drawn. When these other lines were drawn, a repeating pattern was disentangled from it, but until that was done, there was nothing in the design which answered the definition of a repeating pattern—namely, a particular shape which, when repeated, could be made to fill all space. That, of course, was a feature of a great many designs, interlacements of lines, and many Arabesque designs. Those were not "repeats" in the sense in which he had used the word scientifically that evening. But from such designs repeats could be extracted, sometimes on making further dissections by adding certain lines; from many of the designs shown by Sir Francis Piggott on the screen one could without modification make repeats of a particular area. That was the sense in which he had used the word "repeat."

All Sir Francis Piggott's designs were extremely instructive, and repeats could be derived with very little difficulty from them. Sir Francis had spoken about evolution. In the paper that evening, however, he had himself referred in his concluding remarks to the principle of continuous growth of equal and similar and similarly oriented contours placed at points which were uniformly distributed. That was a well-known principle in discussing this matter of repeating patterns which was particularly brought forward by Lord Kelvin in regard to three dimensions in his researches on atomic structure, and which was now being considered and written about by Sir Joseph Thomson, in the same regard. Of course, that was a very interesting principle, but it was not a principle which lent itself to a classification of repeating patterns. What he himself had had in view had been a definite classification, and neither the principle of continuous growth nor the other principles mentioned lent themselves to this purpose. One had to go to the ultimate forms

* "On some discoveries of methods of design employed in Mahomedan art"—this *Journal*, Vol. LIII., March 17, 1905, p. 461.

of things if one was to arrive at a scientific principle of classification, and that was what he had had in mind. Sir Francis Piggott had referred to the cells of bees. Perhaps he was not aware that that subject had been gone into very thoroughly by Cambridge mathematicians, particularly by Dr. Glaisher, of Trinity College, who in a lecture many years ago, referring to bees, had given his opinion without hesitation that the bees were not in it with mathematicians! The mathematicians could make these cells far better than the bees, and as Dr. Glaisher had gone into the matter he (the speaker) naturally assumed that he knew what he was talking about. With regard to this question of continuous growth, Sir Francis Piggott had spoken of spheres with hexagonal surfaces.

Sir Francis Piggott said his scientific terminology might have been wrong. There was a spherical fungus—the lattice moss—which had flat surfaces in pentagonal shapes, and he suggested that there might be a hexagonal shape.

Major MacMahon said that the shape that naturally arose in three dimensions on the principle of evolution was not hexagonal or pentagonal with regard to its surface. It was a solid known as the rhombic dodecahedron which, as it faces, had twelve rhombs. He was very much interested to hear what had been said about Japanese heraldry, but to many designs of the Japanese the same remark applied; they were not repeats, though they could easily be made such. He thought that Sir Hercules Read was quite right in what he had said about the Chinese. He had no doubt that the Chinese mathematicians had gone deeply into this matter, but he wondered sometimes why in Chinese work one saw nowhere any recognition of the stencil repeats. The Moors also, no doubt, knew a great deal more which they did not publish. He had had an interesting letter recently from Dr. Hankin, who had been studying the Moorish designs. These were not directly repeating patterns, at least in a great many cases, but repeating patterns were very easily extracted from them, and he thought that Dr. Hankin had made a great advance in discovering the way in which these Moorish designers went to work. He was to be congratulated on elucidating the methods which they employed.

CORRESPONDENCE.

OIL BEARING NUTS IN GUATEMALA.

Referring to the article under this caption in the *Journal* of June 16th, I would point out that large quantities of Cohune Nuts are annually rotting in British Honduras, merely for the want of a suitable machine to crack the nuts, without breaking the kernels. If the machine referred to is really suitable and can be worked by unskilled labour, it would be a great boon to the Colony to have it introduced there, by bringing it to the notice of the Chamber of Commerce at Belize. The little Colony wants all its resources developed to get it into a flourishing condition, and if these lines were to contribute somewhat to that end, I should be extremely pleased.

H. E. Oswald.

NOTES ON BOOKS.

The Work and Position of the Metallurgical Chemist. By Sir Robert A. Hadfield. London: Obtainable from Messrs. Charles Griffin and Co., Ltd. Sheffield: From Mr. W. H. Seed. 1921.

A well-illustrated volume of a hundred pages, which embodies the matter of the author's address to an assembly of metallurgists at Sheffield.

Sheffield, Lord Palmerston's "Black picture set in a golden frame," and a modern embodiment of the sentiment by which Greek mythology makes Vulcan the husband of Venus, is to Sir Robert Hadfield the high place of the world, and it is evident that he sees everything relating to Sheffield or the steel industry as in a poetic halo. As a man of Sheffield, Sir Robert looks back proudly (p. 13) on the fact that Chaucer recognised the merits of Sheffield products, and on the same page he drifts over to a kindred district in France, Le Creusot and its great forge, where he and his fellow members of the Iron and Steel Institute were so graciously received by Madame Schneider, who is a direct descendant of James II. and Arabella Churchill.

Intense admiration for all honest and faithful labourers is the dominant key-note of the book: the print from the bust of Robert Boyle (frontispiece) being an illustration of this. Boyle is styled the "Father of modern chemistry," and Sir Robert, on a folder opposite p. 22, classifies chemists, with that ready insight which may be expected from an old laboratory worker. The premier position which is claimed for Boyle seems justified when we remember that apart from his definite experimental work, he was the first to present chemistry as an ordered system with clear notions regarding element, compound, mixture, analysis, synthesis and molecular constitution.

Detail and technics in the work before us centre to a considerable extent on the work of the metallurgical chemist in evolving and adjusting qualities of steel as used in the Great War, and as an example of unexpected difficulties which were overcome, reference is made to the adaptation of manganese steel to the construction of the helmets or "tin hats," which became so important towards the close of the war, the difficulty being to reduce the large-

sized ingots of this resistant material to the necessary thickness, or about one-thirtieth of an inch.

Plate 19 shows French, British and German helmets under test conditions, with clear indications as to the superiority of those made of manganese steel, which in this application is the culmination of the work of a long series of British investigators.

Numerous illustrations, many of them portraits, add to the interest of the book.

THE AGRICULTURAL AND FOREST PRODUCTS OF BRITISH WEST AFRICA. By Gerald C. Dudgeon. Second edition. London: John Murray. 1922. 7*s*. 6*d*. net.

Here we have a new edition of a volume in the well-known series issued under the auspices of the Imperial Institute, in which series industrial geography is so usefully and thoroughly studied, and in special reference to the resources of the British Empire.

The large range of products, mainly vegetable, but occasionally animal, here considered, and the many details as to collection, storage or factorage, together with the abundant particulars as to more or less elaborate industrial processes, give the book a somewhat discursive aspect, and the discursive aspect will perhaps tend to make the volume one which the business man or manufacturer can take up with advantage and comfort in leisure moments; indeed, the text (nearly 200 pages) and the numerous maps and inset plates, make the whole a rapidly changing panorama of life and activity in districts where till recent medical studies had borne fruit the white races could only settle at considerable risk. The admirable index of twelve pages links all together, and the item "Silver" in the index led us to p. 55, where we find that, in the Volta cocoa-buying centre, buyers must be provided with silver, notes and cheques not being accepted. Here is an example of the many hints or particulars as to business matters. On the same page is an explanation as to how the native of this district will be contented with less when working for himself than when working for an employer, while on pages 24 and 25 will be found a short account of the three principal considerations which are believed to have influenced Messrs. Lever Brothers in abandoning their oil-products establishment in Sierra Leone, also their concession to work several hundred square miles, Messrs. Lever Brothers having now transferred their works to the Belgian Congo.

Among the photographic illustrations, over 100 in number, the following may be specially mentioned as illustrating industries which are described in the text:—Jolah with hand plough, Indigo Dyers, Out-door Weaver at Pendembu, Straining Oil from the Fibrous Pulp of the Oil Palm, and The Ginnery of the British Cotton Growing Association.

SYNTHETIC TANNINS: THEIR SYNTHESIS, INDUSTRIAL PRODUCTION AND APPLICATION. By Georg Grasser. Translated by F. G. A. Enna. London: Crosby, Lockwood and Son. 1922. 12*s*. net.

True or indubitable tannins are briefly considered, and such syntheses as those of Fischer are touched on p. 25, but we find no reference to any industrial uses of true synthetic tannins; a matter of doubtful practicability owing to the high cost of synthetic tannins. Thus, it may be suggested that the title of the book is not quite appropriate to the contents.

The drift away from true tannins on page 35, and throughout the remainder of the book is very noticeable, as we now find somewhat vague generalisations regarding artificial products which harden or insolubilise pelts, as, for example, aromatic sulphonic conjugates condensed or polymerised with formaldehyde and brought into alcaline solution; these appearing to us in no sense tanning materials, but as rather analogous in their function to tawing agents. It is to be noticed that on page 91 the tone of the book again changes, and we have a eulogium of the modes of manufacture carried out by the "B.A.S.F.," and of this firm's products, which are marketed under trade names: this note of eulogy continues more or less, to the end of the book, but there is one pronounced discord, in the shape of footnote 2 on p. 118 commencing "The translator cannot agree with the author———"

The author's preface should be read with care, especially the patriotic sentiments as to the course suggested making us "—— independent of foreign supplies———"; also as to keeping "within our own borders the vast sums of money required in former days for the purchase of foreign tanning material." Next let the reader note that this preface is dated from Graz, an old centre of the tanning industry in Austria: also that the initials B.A.S.F. stand for the Badische Anilin und Soda Fabrik, one of the huge German chemical establishments with which the author was associated.

We know that aryl-sulphonic condensations with formaldehyde, of the kind favoured by our author, will give a white or whitish product, somewhat resembling a tawed skin, and if such products are termed synthetic tannins, ordinary alum should, we suggest, be similarly classed.

Notwithstanding the emergency service done to both sides in the late war by the use of condensation products of the kind referred to in Herr Grasser's book, and also very concisely and well described by Mr. Henry R. Procter on p. 781, of this *Journal* dated November 8th, 1918, we suggest that further experience is desirable as regards the lastingness of "leather," "tanned" with such products, before we use them in peace times. If we should find it desirable thus to supplement our supplies of natural tannins we can manufacture the new products for ourselves.

APPLIED CALCULUS: AN INTRODUCTORY TEXT-BOOK. By F. F. P. Bisacre. London: Blackie and Son, Limited. 1921. 10*s.* 6*d.* net.

The key-note of this work, addressed primarily to the student of natural or applied science, is the sentiment of human interest in mathematics; an aspect which is so often lost to the student by reason of the habit which so many teachers have of enforcing a detailed study of much complex mechanism with signs and symbols, before the real or spiritual aspect of the subject is presented or even suggested to the learner.

Our author very pronouncedly avoids so sterilising a course, so he leaves over the study of infinite series, for a second step, and he illustrates the use of limits, by an apt reference to a scene of Shakespeare's plays (p. 28), before he attempts the somewhat difficult task of satisfactorily defining the term limit in its shades of theoretical and practical meaning (pp. 83 to 94.).

The author's birth scene of the calculus is laid in 1612, when there was an abundant vintage in Germany, with the consequent shortage of casks and the natural desire to know the contents of any unusual cask which had been filled in the haste of saving the vintage. Kepler, whose astronomical studies had led him to a determination of the areas of closed curves, gave his mind to the new problem, and published his *Nova Stereometra Doliorum*, or, as our author puts it, "The earliest work on the subject, now called the integral calculus." Next follows an explanation of the essentials of Kepler's method so clearly expressed as to be almost a lure calculated to lead the general reader into a new path of study.

In like easy and lucid fashion, the fundamental methods of the calculus are presented, in such order as to maintain interest and a natural sequence of ideas; this occupying about one-third of the book. The remainder, that is to say, the bulk of the volume, is mainly concerned with definite applications of the calculus to actual laboratory problems, about 170 in number; the following being examples of the problems:—Efficiency of ideal Diesel cycle; the Otto cycle and the nearest ideal cycle; Faraday's law of electro-magnetic induction; a reversible chemical reaction, and example of Isothermal Expansion.

Portraits and short biographical notices form a pleasant feature of Mr. Bisacre's book, Newton, the incomparable, holding the place of honour opposite the title page, the remaining 16 portraits being in four groups of four, each group on an inset plate.

LOGWOOD INDUSTRY IN JAMAICA.

Logwood was first introduced into Jamaica from Honduras, in 1715, and was later carried to other parts of the West Indies. It will grow well on all soils, except loose sand and heavy clay, but it grows best and produces a finer heartwood on moist, rich soil where there is an abundance of vegetable matter. The climate must be hot, but not arid, although it has been found that when the plant becomes firmly rooted it stands a drought very well. Very little attempt is made to cultivate it, and most of the wood is cut from self-sown trees, which are usually found on waste lands unsuitable for cultivation.

Until quite recently, writes the United States Vice-Consul at Kingston, the production of logwood crystals has been very remunerative. A large dyeworks plant in Jamaica has been paying only £40 for sufficient raw material to make one ton of crystals, which sold in London for £200. An association of logwood growers has been formed, however, for the purpose of obtaining higher prices for their logwood. Pending the formation of this Association, the demand for both logwood and crystals declined to such an extent that the local factories were forced to close down.

There are three plants producing logwood extract in Jamaica, one in Spanish Town, one in Lacovia, and one in Savanna-la-Mar. The plant at Spanish Town is the largest. Its minimum crushing capacity is 20,000 tons (of 2,240 lb.) per year, while the plant at Lacovia has a capacity of 12,000 tons per year. Figures are not obtainable for the plant at Savanna-la-Mar, as it was completely destroyed by fire shortly after its completion. It requires from 8 to 9 tons of logwood to produce 1 ton of crystals, and a somewhat less amount to produce 1 ton of liquid extract. Crystals are always shipped in casks containing 320 pounds, while the liquid is shipped in barrels containing 650 pounds.

The following table gives the exports of logwood and extract to the United States and the United Kingdom for the years 1918 and 1919:—

Exported to	Logwood. Tons.	Value. £
United Kingdom:		
1918	1,360	4,894
1919	3,153	16,080
United States:		
1918	14,133	50,879
1919	13,928	71,032
	Logwood Extract. Packages.	Value. £
United Kingdom:		
1918	20,459	306,890
1919	22,090	331,800
United States:		
1918	550	8,250
1919	329	4,935

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2

NOTICE.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO SIR DUGALD CLERK.

The Council of the Royal Society of Arts attended at Clarence House, St. James's, on June 29th, when His Royal Highness the Duke of Connaught and Strathearn, K.G., President of the Society, presented the Albert Medal of the Society for the present year to Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S., "in recognition of his important contributions, both theoretical and practical, to the development of the Internal Combustion Engine."

The following members of the Council were present :—

Mr Alan A Campbell Swinton, F R.S. Chairman of the Council, Lord Askwith, K B.E, D.C.L., Sir Charles Stuart Bayley, G C I E, K C S I., Lord Blyth, Sir William H Clark, K C.S.I, C M.G, Mr Edward Dent, M A, Sir R. A. Hadfield, Bt., D.Sc, D Met, F R S., John S Highfield, M.Inst.C E., M.I E.E., Major Percy A. MacMahon, R A., LL.D., Sc D., F R S, Dr. William Henry Maw, M.Inst.C.E, Mr. John Slater, F.R I.B.A., Mr. James Swinburne, F.R S., Sir Philip Watts, K.C.B., LL D, F.R S., with Mr. G. K. Menzies (Secretary of the Society) and Mr. S Digby, C I E (Secretary of the Indian and Dominions and Colonies Sections).

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The One Hundred and Sixty-eighth Annual General Meeting for receiving the Report of the Council, and the Treasurers' Statement of Receipts and Payments during the past year, and also for the Election of Officers and New Fellows, was held in accordance with the By-laws on Wednesday, June 28th, at 4 p.m., MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

The Secretary read the notice convening the meeting, and the Minutes of the last Annual General Meeting held on June 29th, 1921.

The following candidates were proposed, balloted for, and duly elected Fellows of the Society :—

Bancroft, William Wilfrid, Ilford, Essex.
Beall, F. F. Detroit, Mich., U.S.A.
Chaudhuri, S. N., M.A., Calcutta, India.
Cook, C. F., Hove, Sussex.
Dalal, Dadiba Merwanjee, C I E., India Office, S W.
Doyle, William, B.A., Loughborough
Drummond, L. E, Edmonton, Canada.
Eardley, Walter H., D Sc., Salt Lake City, U.S.A.
Frank, John Williamson, Vancouver, B C.
Galliver, George Alfred, M D., Holyoke, U S.A.
Gillam, William Thomas, Luton, Beds.
Jamieson, A. Eldon, Edmonton, Canada
Javeri, Ratilal C, Bombay, India.
Kaye, Robert Walter, Leicester.
Kilachand, T., Bombay, India.
Macartney, Rt. Hon Sir William Grey Ellison, K.C.M.G., London.
McLeish, Rev Alexander, Rajputana, India.
Mappin, Godfrey Edward, Ingatestone, Essex.
Mukherjee, Tarak Nath, Bengal, India.
Palairet, Charles R., Indore, India.
Roberts, Arthur Lawrence, Birmingham.
Small, Frank S., B.Sc., New York City, U.S.A.
Stannard, H. Sylvester, Bedford.
Sullivan, Haldane Herbert, Risca, Mon
Worden, Edward Chauncey, Ph.C., D Sc., F.C.S., New Jersey, U S.A

THE CHAIRMAN appointed Mr. Byron Brenan, C.M.G., and Mr. Charles Oliver Barber, B.Sc., F.C.S., Scrutineers, and declared the ballot open.

THE CHAIRMAN said the first item of business was a very pleasant one, as it was his duty, on behalf of the Council to present a cheque for fifty pounds to Mr. George Davenport, the Chief Clerk, on his completion of 50 years' service with the Society. They all knew Mr. Davenport, and he did not think it was necessary for him to say very much about him. Mr. Davenport had been connected with the Society for fifty years, and he had contributed largely to the success of the meetings by the way in

which he had handled the lantern and by the valuable assistance he had rendered whenever preparations were required for experiments, etc. Speaking from his own experience, and also what he had heard from other lecturers, he said Mr. Davenport had been of the greatest service in making preparations for papers and lectures, and had shown great willingness to do everything he could to help them. He had very much pleasure in presenting the cheque to Mr. Davenport and wished him long life to continue in the Society's service.

MR. GEORGE DAVENPORT thanked the Chairman for the kind words he had spoken and the Council for their generous gift. He said it hardly seemed possible so long a time had elapsed since he first came there, but he thought this was largely due to the interesting nature of the work, and to the very great pleasure it had given him to help in his own small way in carrying it out. He greatly valued this expression of appreciation of the Council, and hoped he might have opportunities in the future of still further deserving their approval.

THE SECRETARY then read the following Report of Council:—

REPORT OF COUNCIL.

I.—THE SOCIETY'S HOUSE.

In the last Annual Report it was stated that the question of the Society's House was causing the Council grave concern. The lease was terminable in March, 1922, and a sum of £50,000 was required to purchase the freehold of the property and to provide for necessary decoration and repairs. Towards this amount some £8,000 had been promised by several members of the Council and their friends, but in the generally depressed condition of the country there seemed to be but little hope of raising the remainder. At this point, however, a gentleman, who desires to remain anonymous, came forward and contributed the munificent sum of £30,000. The Council thereupon decided to issue an Appeal to the Fellows, with the result that up to the present, about £42,500 has been obtained. The Council have great pleasure in reporting that they have now secured the freehold of the premises; but in order to provide for the legal expenses and for alterations, decorations, etc., they have been compelled to arrange for a running overdraft with their bankers. They take this opportunity of again appealing to the liberality of the Fellows to assist them in paying off this overdraft.

Now that the house has become the permanent property of the Society, the Council are anxious to make it as convenient and attractive as possible for the Fellows. They desire to restore it, so far as is compatible with modern requirements, to the state in which it was left by its architects, the Brothers Adam. With this end in view they have appointed Mr. Arthur T. Bolton, F.R.I.B.A., Curator of the Soane Museum, to take charge of the renovations. It is hoped to make the library into a handsome and comfortable club room; the Great Hall will be entirely redecorated and provided with a new system of ventilation; and the entrance hall will be considerably enlarged and improved. The heating and lighting throughout the building will receive very careful attention, and every effort will be made to encourage Fellows who desire to use the Library and Reading Room.

In order to carry out this work it will probably be necessary to close the Library from the beginning of July to the end of November.

II.—ORDINARY MEETINGS.

Mr. Alan A. Campbell Swinton, in the introductory remarks of his inaugural address, summarised the position of the Society with regard to the purchase of its house, and described the progress that had been made with the Purchase Fund. He also referred to the effects of increasing the annual subscription from £2 2s. to £3 3s., a step which the Council had reluctantly felt themselves compelled to recommend in view of the greatly increased cost of printing and maintenance charges generally. Proceeding then to the more particular subject of his address, "Wireless Telegraphy," he described some further developments in addition to those dealt with in the address which he gave at the opening of session 1920-21, particularly the Universal Amplifier, and the Johnsen and Rahbeck telephone. Messages were transmitted by wireless telephony from Victoria Street, and speech and music from Lewisham. The music was recorded on a phonograph in the lecture room, and was repeated to the audience from the phonographic record.

Wireless telegraphy was also dealt with by Professor J. A. Fleming, who delivered the fifth Trueman Wood Lecture. It is

just twenty-one years since the first wireless station was erected at Poldhu in Cornwall, and Professor Fleming, who called his lecture "The Coming of Age of Long Distance Wireless Telegraphy, and some of its Scientific Problems," described the advances that have been made during that period. With many of these advances Professor Fleming's own name is closely associated—particularly with the thermionic valve, which, in the words of Senatore Marconi, who seconded the vote of thanks to the lecturer. "was perhaps one of the most important contributions to the practice of long distance communication." After giving an historical account of these developments, Professor Fleming discussed in an extremely interesting way various problems still unsolved in connexion with radiotelegraphy, *e.g.*, the methods in which electromagnetic waves are propagated round the earth, the existence of an æther, etc. The lecture, which was brilliantly delivered and illustrated by numerous experiments, was a remarkable addition to the fine series of Trueman Wood lectures.

The Industrial Fatigue Research Board was appointed in 1918 by the Medical Research Council and the Department of Scientific and Industrial Research, and its Secretary, Mr. D. R. Wilson, gave an account of the work of the Board and outlined its future policy. Investigations have been conducted in various trades with a view to ascertaining the causes of variation in output, sickness and mortality, labour turnover, lost time, and accident incidence. Such questions as the effects of temperature, humidity, lighting and ventilation on the efficiency of the worker have also been considered, and details were given of the results achieved by several particular investigators. Mr. Wilson concluded with a powerful plea for the continuance of the work of the Board in view of its importance in connexion with the increase of production, and also because of its indirect effect in bringing together employers and employed and giving each side a fresh insight into the other's difficulties.

An interesting paper, entitled "Modern Buildings in Cambridge and their Architecture," was read by Mr. T. H. Lyon, Director of Design in the University School of Architecture, Cambridge. Mr. Lyon drew particular attention to the work of William Wilkins, Basevi, the architect of the Fitzwilliam Museum, Sir Gilbert Scott, Scott the Younger, Bodley, the new buildings for the School of Engineering, and the National Institute of Agricultural Botany. Mr. Lyon is himself the architect of one of the finest new buildings in Cambridge, the chapel of Sidney Sussex College, which exemplifies most of the features of "the grand manner"—the characteristic, according to Mr. Lyon, of all the finest architectural work in Cambridge.

Mr. Noel Heaton's paper on "The Preservation of Stone" will be found extremely useful as bringing together in one article a great quantity of information which has hitherto been scattered so broadcast as to be extremely difficult to find when wanted. He summarised all the principal processes at present in use for preserving stone, described their action and indicated generally when they could be used with advantage. As a result of his paper it would appear that a process likely to do much real good has yet to be found. "Preservative treatment," said Mr. Heaton, "should only be employed where it is certain that it can, at the worst, do no harm." He pleaded, however, for further study of the subject, and for constant exchange of experience amongst those engaged upon the problems concerned.

Towards the end of the session Mr. Heaton read a second paper, "The Production of Titanium Oxide and its Uses as a Paint Material." Although titanium is known as a "rare" metal, titanium oxide occurs in small amounts in almost all rocks: in particular it is estimated that in the neighbourhood of Stavanger, Norway, 30 million tons of titaniferous iron ore are available. Works have been established there which are now actively engaged in the extraction of the oxide. The process of manufacture by hydroelectric power was fully described, and the qualities of the oxide as a pigment were discussed. It is claimed that titanium is entirely free from the poisonous elements present in white lead; the pigment has great chemical stability, with remarkable power of resisting the weathering effects of the atmosphere; its opacity is of a high order; and on these grounds Mr. Heaton is of opinion that the pigment is destined to become one of the most widely used and valuable materials at the service of the painter.

M. Emile Cammaerts, who has perhaps done as much as any one to promote friendly feelings between this country and Belgium

and France, read a paper on "Literature and International Relations." One of the great lessons of the European War has been to teach the nations the necessity for mutual understanding, and there is no surer way to arrive at such an understanding than by study of foreign literature and art in which the temperament of a nation is most adequately expressed. He emphasised the practical importance in our schemes of education of history, geography and modern languages; he discussed the part played by journalism in affecting the outlook of peoples towards one another, and in particular he pointed out the need for foreign correspondents to have a thorough knowledge of the countries in which they reside in order that they may be able to provide correct information, and further that they should be able to present such information in a manner that will appeal to the temperament and inclinations of the people for whom they write.

Sir Walter Beaupré Townley drew attention to the possibilities of trade with the Netherlands East Indies. With their vast area of 738,000 square miles, and population of some fifty millions, these islands produce large quantities of sugar, coffee, rubber, tea, tobacco, cinchona bark, cocoa and fibres, whilst, in addition to these, rice, coconuts, corn, cassava and peanuts are grown by native agriculturists. On the other hand, there are many articles required by the Netherlands East Indies, of which the principal are textiles of all sorts, cement, iron and steel manufactures, beds, boots and shoes, glass and earthenware, drugs and chemicals, foodstuffs, mineral waters, coal, artificial manures, dyes, etc. There seems to be little doubt that a large share of this trade might well come to this country, if our merchants would take the trouble to provide what is wanted in the way that it is wanted. When German firms send out Dutch-speaking representatives, who quote prices in gilders for goods delivered at the factory, there is not much hope for the English-speaking representative who quotes in pounds sterling for goods "f.o.b. Southampton."

"Some recent Advances in the Biological Theory of Sex," was the title of a paper in which Mr. Julian Huxley brought together the results of the latest investigations into this most difficult and complicated problem. It is apparently the case that the primary distinction of sex depends on the presence in the sexual cells of a particular enzyme, which is stored up in the X-chromosome. Again, it seems to be proved that the rate at which the male-determining hormone, or the female-determining hormone, developes varies with conditions which can be altered, so that not only primary, but also secondary sexual characters can be changed. A slide was exhibited of a guinea pig which, though born a male, was shown in the act of suckling young—not its own, however. Of course a great deal of work will have to be done before it will be possible—if ever it is—to determine the sex of the next calf or chicken; but the problem is attracting a number of investigators in different parts of the world, and fresh data are being gradually accumulated.

Under the title of "Photosculpture," Mr. Howard M. Edmunds described a process invented by himself, whereby it is possible by means of photography, to produce carved replicas in relief or in the round of any solid object. It is hardly feasible to give, in a few sentences, any adequate idea of the process. In explaining it, Mr. Edmunds exhibited a kinematograph film, which showed the method of operation very clearly. He also displayed a number of specimens of bas relief portraits and other works, produced by his methods, which seemed to indicate very considerable possibilities for the process.

Mr. Arthur Wilcock gave a full description of the process of surface printing by rollers in the cotton industry, a process that has been in use for many years in the printing of wall papers. The more usual method of printing in the textile industries, is by means of the copper roller, the pattern being engraved on its surface, intaglio fashion. In surface printing the pattern is raised above the roller. The qualities of this process are its softness of outline and general colour tone, and the finished print bears a strong resemblance to hand block work—so much so that it is sometimes mistaken for it even by members of the trade. It is, however, much less permanent than the hand block process print, by reason of its more superficial and rapid process.

In a brilliantly illustrated experimental paper, Mr. E. V. Evans discussed "Some Solved and Unsolved Problems in Gas Works Chemistry." He described first the means taken to remove naphthalene from gas by washing it in steam-distilled

oil; the method of eliminating sulphur compounds was illustrated, and the problem of getting rid of hydrogen sulphide was discussed. The dangers of carbon monoxide, which have recently been a subject of much controversy in the newspapers and elsewhere, were alluded to, and Mr. Evans contended that with four people smoking cigars in a room, as much carbon monoxide would be contained in the air as would be given out by an escape of gas which could be detected by the nose. Finally, the questions of smokeless fuel and low temperature carbonisation, were discussed, and the effect of smoke on the condition of the lungs was illustrated.

The recent report of the Departmental Committee on the Teaching of English, drew attention, among other things, to the need for proper speech training in our schools. This point was taken up and elaborated by Mr. Cloudesley Brereton, whose long experience as an Inspector of Schools, under the London County Council, enabled him to speak with authority on the subject. He pleaded for systematic training in gesture, pronunciation, intonation and rhythm. A number of special schools are already doing much good work in this direction, but in Mr. Brereton's opinion, their status is not yet adequate, and he thinks that they ought to be definitely recognised as an integral part of the national system. In fact, he pleaded for "the eventual recognition of a faculty of diction, whose constituent colleges should be united with the present colleges of music in a national Conservatoire, the whole thus forming part of a national University."

By an agreement between the British Museum and the Department of Scientific and Industrial Research, a laboratory has been provided at the Museum where experiments are conducted with a view to discovering the best means of preserving the objects exhibited there. The laboratory is under the charge of Dr. Alexander Scott, who read a paper entitled "The Restoration and Preservation of Objects at the British Museum," in which he described the work carried out by him during the last two years. The problems presented are extremely various, the objects are made of all kinds of materials, and most of them have been subjected to various chemical actions before reaching the museum. Dr. Scott discussed the treatment of objects in stone, paintings on rock, canvas and paper, enamels, and objects in wood and sundry metals. In view of the enormous value of the contents of our museums, any sound and scientific steps taken towards their restoration and preservation deserves the warmest welcome.

Mr. Emanuel Moor gave an interesting account and demonstration of his invention, the Duplex-Coupler Pianoforte. The principal feature of the instrument is that it possesses a double key-board, the notes in the upper being an octave higher than those immediately beneath them in the lower keyboard. In this way it is possible, simultaneously, to strike two notes, which on the ordinary keyboard are ten or even twelves notes apart, with the greatest ease. Further, the two keyboards can be coupled together, so that passages in double octaves present no difficulties. By a simple device the tone of the piano can be changed into one closely resembling that of the harpsichord, and this produces an excellent effect when the performer is playing classical music originally composed for the harpsichord.

Mr. W. A. Appleton, who has been Secretary of the General Federation of Trade Unions since 1907, read a paper on "The Proper Functions of Trade Unions." He considers that these include every problem connected with employment and unemployment, e.g., wages, hours, conditions under which employment is provided, safe-guards against accident and industrial disease, compensation where disease or accident results, and provision against unemployment. He does not include among their proper functions such objects as the provision of capital, the discovery and exploitation of markets, or the actual direction of business. While claiming for the unions the right to use their votes and influence in favour of any political party that can help them, or against any party that is hostile to them, he is opposed to their forfeiting their autonomy by tying themselves definitely to any particular party; and he strongly deprecates strikes and threats of strikes to attain political ends.

In his paper, "Certain Aspects of the Problem of Exchange Stabilisation," Mr. Oswald T. Falk criticised the authorities of the Bank of England for having maintained the bank rate at so high a figure for so long. By reducing the rate at an earlier date he maintained that the depression from which industry is suffering would have been lightened, and he urged

that there is as much justification to-day for a 2 per cent. rate as there was in the years following the Baring crisis. He considers that there are three important preliminary conditions of an attempt to stabilise exchange:—(1) A practicable settlement of the Reparation and Inter-Allied Debt problems. (2) A reduction in the size of the favourable trade balance of the United States, and the maintenance of this reduction for a considerable period. (3) A restoration of complete confidence in the ability and determination of our Government to balance the budget. Mr. Falk also criticised the Reports of the Cunliffe Committee of 1918 and 1919, and urged the necessity for appointing a new committee to consider a fresh financial policy.

The problems of protecting the coast against erosion are among the most difficult that engineers are called upon to solve. The conditions vary so much in different localities that measures which might be successful in one place are wholly unsuitable in another. Great care must be taken, also, to ensure that the steps taken to protect one part of the coast do not injure the adjoining shore. Professor E. R. Matthews, in a comprehensive paper, summarised the facts about coast erosion, so far as they are generally recognised. He described the various causes of erosion, and the different types of artificial protection works. He also dealt with the somewhat controversial subject of deep sea erosion, the formation of salt marshes, subsidence, and the findings of the Royal Commission on Coast Erosion.

The late Mr. Holman Hunt made continuous experiments in order to test the permanency of various pigments. Some of his experimental canvases came into the hands of Professor A. P. Laurie, who described the results. From these it would appear that the accepted list of pigments as used to-day is reliable with the possible exceptions of cobalt yellow in oil, pale cadmium yellow and chrome yellow. The question of the darkening of the oil was also discussed, and Professor Laurie was inclined to attribute this to the use of lead driers. These, according to the best modern practice, are now excluded from oils and varnishes.

"The design of Repeating Patterns for Decorative Work" was the title of a paper read by Major Percy A. MacMahon. A repeating pattern was defined as "a figure of such a shape that a number of them may be fitted together so as to cover flat space without overlapping, and without leaving interstices." The only regular polygons which are repeating patterns are the triangle, the square, and the hexagon. These were dealt with, after a brief account of the scientific principles upon which repeating patterns can be constructed and classified; and a large number of examples were shown on the screen of other patterns derived from these three figures. Finally Major MacMahon exhibited assembled designs made from a great variety of repeating patterns. Most of these have never been utilised for practical application, and it seems possible that new sources of motifs may be suggested by them to designers.

"The Power Resources of Ireland (Coal, Peat and Water Power)" was the title of a paper read by Mr. George Fletcher. The annual output of Irish coal is only about 90,000 tons, while the amount imported is 4,500,000 tons. The output of the Irish mines could, no doubt, be considerably increased, although the seams are thin, and means of transport are not all that they might be; but Mr. Fletcher is of opinion that Irish peat will prove a serious rival to coal. The reserves of peat are enormous—sufficient to meet the present fuel requirements for 200 years. The drawbacks of peat are its wetness and its bulkiness. Some interesting work has recently been carried out in connexion with the maceration of peat, and an account of this was given in the paper. The Water Power Resources of Ireland Sub-Committee have investigated the potentialities of four of the most important Irish rivers, and have come to the conclusion that 500,000 W.H.P. can be continuously developed for the whole country. In order to secure efficiency and economy in the utilisation of the various sources of power, Mr. Fletcher urges that the State must take control of them, and that no time should be lost in dealing with the matter.

In a paper entitled "The Problem of Provincial Galleries and Art Museums, with special reference to Manchester," Mr. Lawrence Haward described the part played by provincial institutions in the artistic and educational life of the communities surrounding them. The Manchester Art Gallery, of which Mr. Haward is curator, has done excellent work in holding exhibitions of various kinds—as many as

sixty within the last ten years—including paintings, drawings, etchings, porcelain, pottery, printing, theatrical designs, American architecture and so forth, while numerous lectures have been given in connexion with these special exhibitions. The Manchester Education Committee have taught the children to regard a visit to a gallery as a perfectly normal experience. Mr. Haward also discussed a number of points of interest to all connected with museums and galleries, *e.g.*, the best means of showing the exhibits, the question of refusing gifts that are of poor quality, the methods of purchasing specimens, and the encouragement of a spirit of co-operation among local institutions.

III.—Indian and Dominions and Colonies Sections.

The Indian Section held five meetings, the Dominions and Colonies Section four, and the two Sections jointly three. The Indian papers were:—"The Timbers of India," by Mr. Alexander L. Howard; "The Indigo Situation in India," by Professor Henry E. Armstrong; "The Need for an All-India Gauge Policy," by Mr. F. G. Royal-Dawson; and "Irrigation Enterprise in India," by Mr. F. W. Woods. The third annual Sir George Birdwood Memorial Lecture was on "Indian Art and Muhammadan Culture," the lecturer being Professor Sir Thomas W. Arnold. The papers read in the Dominions and Colonies Section were as follows:—"British Columbia: the Awakening of the Pacific," by Mr. F. C. Wade; "The Timbers of British Columbia," by Mr. William Turnbull; "New Zealand," by Lieut.-Col. Sir Thomas Bilbe Robinson; and "Tanganyika (formerly German East Africa)" by Major Sir Humphrey Leggett. The papers read at the joint meetings were: "An Imperial Airship Service," by Mr. A. H. Ashbolt; "Lignites and Brown Coals, and their Importance to the Empire," by Professor W. A. Bone, and "Imperial Wireless Communication," by Professor W. H. Eccles.

A year ago Professor S. R. Troup, in his capacity as a scientific botanist and forestry expert, dealt with the less familiar but more ornamental of India's timbers; Mr. Howard, a business man of long and wide experience, devoted his most useful paper to a practical consideration of the problem connected with the better development of this potentially valuable State asset, a problem that is engaging and for some little time past has engaged the earnest attention of the Indian authorities. Some encouraging instances were given of the recent utilisation of the beautiful woods referred to in important buildings here, including the London County Hall and the Bank of England's new premises in Finsbury Circus. The advisability of these and the other examples mentioned being copied by the Royal Society of Arts in the renovation and redecoration of its premises was suggested and seemed to meet with general and warm approval. Professor Armstrong continued the rather melancholy "story of indigo," begun by him in the paper he read three years ago. He now reaffirmed with greater emphasis than ever his belief in a secure future for the natural dye. Not only has indigo a markedly higher value as a dyestuff than indigotin pure and simple, but it may well happen, he pointed out, that not a few natural dyestuffs may once more be in demand because of the difficulty of obtaining the raw materials of the artificial substitutes. He laid stress on the extraordinary value of an experimental inquiry, such as Mr. Davis has initiated, into the requirements of a leguminous plant so typical as that yielding indigo, and deplored the discontinuance of the work of so exceptionally capable an inquirer. "Agriculture," Professor Armstrong said, "is the chief industry of the country, yet it is to be deprived of scientific aid when it is in sorest need of help." On this point he had the powerful support of the Chairman of the meeting, Sir Thomas H. Holland, who said that it would be for the benefit of India if the discussion of that evening helped the Government to re-open the question afresh. In urging the need for an All-India gauge policy, the ex-Chief Engineer to the Indian Railway Board submitted two questions for consideration: (1) Is the perpetuation of the dual standard desirable in the public interests and (2) if not, is alleviation of the evil financially practical? He answered the first question in the negative and the second in the affirmative, arguing that to secure continuity of policy in the direction of unification the construction of new metre gauge lines should be restricted by legislation. Sir William M. Acworth, chairman of the representative committee which the year before last, at the request of the Government, searchingly inquired into the administration of Indian

railways, made a weighty contribution to the discussion. He urged that what is wanted is a "policy" and not legislation. That policy ought to be threshed out on the understanding that it would be permanent and not interrupted by financial opportunism. Sir Thomas Arnold reminded his distinguished audience that the modern historian, particularly if he be a Frenchman or a German, throws his net wide to gather matter for his account of any period and is no longer content to rely merely on the written word of the chronicler. One of the results of this wider outlook has been the use of illustrations even in serious works of historical research. This new line of investigation was followed by Sir Thomas Arnold in his scholarly and admirably-illustrated lecture on "Hindu Painting and Muhammadan Culture." The study of India, as the lecturer observed, is our peculiar domain; no nation possesses so rich a store of material for the purpose as exists in the records and manuscript documents of all kinds lying in the great collections of this country; written and printed sources are indeed receiving attention, but hitherto little use has been made of pictures as aids to historical research, though they have not been entirely unregarded by students of art. Sir Thomas Arnold mentioned that he selected his subject as being one which he knew "would have gained the approval of the great man in whose memory this annual lecture was instituted." The interest of the occasion was enhanced by the presence in the chair of Viscount Peel, this being one of the earliest, if not the first of his public appearances since his appointment as Secretary of State for India. The ex-Governor of Bengal, Lord Ronaldshay, also took part in the proceedings.

The exhaustive paper on "Irrigation Enterprise in India" consisted mainly of a searching examination of the "greatest project for perennial canal irrigation of modern times," the Sukkur Barrage Scheme, which aims at irrigating 5,300,000 acres, rather more than the total culturable area of Upper and Lower Egypt, and is estimated by the Government to cost some twelve millions sterling, though according to Mr. Woods, it will involve an expenditure of not less than £17,000,000. As the engineer who for some years has controlled the administration of the magnificent system of "canal" irrigation in the Punjab—from a material point of view one of the greatest achievements of British rule—Mr. Woods holds that the proposed undertaking is unnecessary, and he supports this contention by pointing to other perennial canals in the peninsula that are fed from their parent rivers without the help of barrages. Although the Sind proposal has, subject to compliance with certain financial arrangements, received the approval of the Secretary of State, Mr. Woods urges that the question should be re-opened and submitted to the adjudication of a committee of experts.

In his brilliant paper on the awakening of the Pacific, Mr. Wade asked the question what is the part which the prosperous and richly-endowed province he so ably represents in the Motherland—British Columbia—is likely to play in the "most momentous event of the Twentieth Century?" The whole answer, he said, depends upon the resources which she is able to contribute to the giant development, particularly upon the stores of energy which she is able to employ. The extent of the resources of all kinds is indeed formidable—timber, coal, water-power and iron, not to mention climate and sunshine. Vancouver Island has been called the "Madeira of the Pacific"; Mr. Wade terms British Columbia the "Riviera of Canada." One of the prominent activities of the province, the development of its forest land, estimated at 149,000 square miles, was described in detail later in the session by Mr. William Turnbull, the Timber Commissioner to the Government of British Columbia. Sir Thomas Robinson, in his paper, said little about the economic problems of New Zealand, which have received attention in previous sessions, confining himself, as a visitor, mainly to a very appreciative account of the many attractions which that picturesque and inviting country offers to tourists, who, it seems, are visiting the Dominion in increasing numbers.

A feature of Sir Humphrey Leggett's paper, which may be regarded as complementary to the one he contributed to the Society a few years ago—"The Economic Development of British East Africa and Uganda"—was the earnest plea it contained for a definite policy in the administration of the extensive mandated territory, Tanganyika, which, as a result of the War, has passed into our hands and whose area equals that of France and Germany combined. Sir Humphrey Leggett described

the new possession as a country destined for a carefully balanced combination of plantation development and native crop production and, except for a comparatively small patch or two, as not suited for European settlement on Colonial lines, namely, farming and ranching. The present population of the British group of East African countries, including the recent addition dealt with, is 12,000,000. In a hundred years "with the *Pax Britannica*, the British pharmacopæia and good government" it may be estimated at 50,000,000. "The Roman Empire in Africa covered 600 years of time. In less than half that period tropical Africa will have her hundreds of millions of British native subjects." Will they, Sir Humphrey asked, be a blessing or a curse ? What is done during the next decade, he said, will decide the answer.

Mr. Ashbolt devoted a portion of his able and comprehensive paper on an imperial airship service to a review of the situation created by the decision of his Majesty's Government to eliminate the dirigible from the scheme of defence. He recommended that the threatened vessels and plant be utilised experimentally for two years, contending that financially the idea was feasible provided the Governments concerned combined to furnish a subsidy of £500,000, and that part of the mails were conveyed in the airships. Major-General Sir William Brancker, however, seemed to doubt whether any subsidy would be necessary, in view of the high fares for passengers that might be looked for. He declared that he absolutely believed in the airship. The views of Mr. Holt Thomas, who was abroad at the time, were at his request communicated to the meeting. He also expressed his belief in airships for commerce, but was rather averse from plunging into a definite service round the world until further data have been obtained. In the valuable paper read by Professor Bone, it was shown that whilst Great Britain itself is almost destitute of lignites (the well-known Bovey Tracey deposit in Devonshire being the only important one), the solution of the various technical difficulties associated with their efficient use is of especial importance to Canada and Australia, as well as to other parts of the Empire. Professor Eccles's important paper, which has attracted an unusual amount of public attention, contained what he himself called a plain statement of the facts, historical, scientific and technical, which ought to be in possession of those wishing to form their own opinion upon the proposal to erect an Imperial Chain of Wireless Stations. The President of the Empire Press Union, Viscount Burnham, occupied the chair, and Senator Marconi was one of those who made interesting contributions to an exceptionally good discussion.

IV.—Cantor Lectures.

The first course, "Processes of Engraving and Etching," was delivered by Mr. Arthur M. Hind, Slade Professor of Fine Art in the University of Oxford. The three lectures were devoted respectively to wood-cut, line-engraving, and etching. In each case he described the process and its origin, and showed examples of the work from its earliest to its latest developments.

Mr. C. Ainsworth Mitchell gave the second course on "Inks." In the first lecture, which was largely historical, he traced back the history of ink manufacture to about 2,000 B.C. in China, where it was conducted on much the same lines as were followed in this country up to comparatively recent times. In his subsequent lectures he described the nature and manufacture of many kinds of ink, and incidentally showed how an expert knowledge of the composition of inks had proved useful in trials for forgery and other crimes.

Professor Alan F. C. Pollard delivered the third course on "The Mechanical Design of Scientific Instruments." This is a subject which does not seem to have received as much attention as it deserves in this country, and the lectures were much appreciated by the large audience who attended them. Professor Pollard showed some extremely beautiful but simple designs, and explained the principles on which the manufacture of scientific instruments should be based.

The fourth and final course was given by Mr. Guy Radcliffe on "The Constituents of Essential Oils." The methods of growing the raw material and of the various processes of manufacture were fully described, and the lecturer strongly urged the necessity for further research in the subject. Nearly all the materials from which essential oils are procured can be obtained within the British Empire, and, in Mr. Radcliffe's opinion, the manufacturers of this country have it in their power to secure the trade of the world.

V.—Shaw Lecture.

Sir Thomas Oliver, in delivering the Shaw Lecture, chose as his subject "Alcohol n relation to Industrial Hygiene and Efficiency." He discussed the physiological effects of alcohol upon the brain, its value as a food, and the connexion between week-end drinking and the loss of time and increase of accidents caused by this habit. Reference was made to the great experiment in Prohibition being carried on in the United States at present. This is being watched with great interest by scientific observers, and the results of a trial on such an enormous scale will go far to decide the question whether, on the whole, alcohol is beneficial or injurious to the worker.

VI.—Dr. Mann Juvenile Lectures.

It was announced in the last Annual Report that the Society had received, under the terms of the will of the late Mrs. Charlotte Elizabeth Mann, a legacy of £1,000, to be devoted in the first instance to the institution of a course of lectures to be known as the "Dr. Mann Juvenile Lectures." The first course under this Trust was delivered during the Christmas recess by Dr. William Reginald Ormandy, his subject being, "Clay—What it is—Where it comes from—and What can be done with it." He described the origin of clay, and its principal characteristics, and gave some account of the history of the principal industries in which it is used. The lectures were illustrated with a number of experiments, whilst two employees from Messrs. Doulton and Co.'s works gave an exhibition of the use of the potter's wheel in throwing various forms of pottery.

VII.—Albert Medal.

The Albert Medal of the Society for 1922 has been awarded by the Council, with the approval of the President, H.R.H. The Duke of Connaught and Strathearn, K.G., to Sir Dugald Clerk, K.B.E., F.R.S., D.Sc., LL.D., in recognition of his important contributions, both theoretical and practical, to the development of the internal combustion engine, which in its later forms has rendered aerial navigation possible, and is also so extensively employed in the motor car, and in the submarine and for many other purposes.

Sir Dugald Clerk's work may be divided into two categories—his specific inventions and his general scientific and educational work. Of his actual inventions, no doubt the best known and the most far-reaching, is that of the Clerk cycle, in which an explosion is obtained at every outward stroke of the piston, which has been, and still is, very widely employed in various guises. In addition to this, his name is well known in connexion with many other inventions relating to the internal combustion engine, such as the flame starter for gas engines and the platinum grid igniter.

Brilliant and valuable as his inventions have proved, it is his scientific and educational work which has made his name so deservedly famous, and has been so largely responsible for the rapid development of the internal combustion engine. Successful invention implies wide imagination coupled with sound judgment; scientific and educational work such as Sir Dugald Clerk has done, and is doing, requires these qualities and many more. At the time when he first devoted his attention to the internal combustion engine, little was known of the true principles involved. Under his handling, vague superstitions and purely empirical rules vanished before logical and reasoned theoretical treatment.

He set himself the task both of searching out the true principles on which all internal combustion engines operate and of teaching these principles to others. For these two tasks no man could be better fitted; his clear thinking enabled him very quickly and surely to sift out the essential problems and his brilliant research work to solve them. Still more valuable, his peculiarly lucid expositions of his discoveries and of his lines of thought, have enabled others, far less gifted, to follow him. Indeed, nearly all the important developments of the internal combustion engine during the last thirty years are the direct outcome of Sir Dugald Clerk's work and teaching.

Born in 1854 it was in 1878 that he produced the first gas engine operating on the now well-known Clerk cycle. After this, for some years he devoted himself exclusively to the study of the internal combustion engine, and the fruits of his investigations he published in 1886 in a book on "The Gas Engine," which has become a standard work on the subject. During this early period, he read several papers, the most important of which was one on the theory of the gas engine, read in 1882

before the Institution of Civil Engineers, for which he was awarded the Watt Medal; in this paper he discussed the theory of compression and proved definitely and numerically, the relative improvement in thermal efficiency to be gained thereby. The paper, in fact, established the well-known air standard of efficiency, a standard which holds to this day as the basis of comparison for all internal combustion engines. This paper was followed in 1886 by a second and almost equally important paper on the explosion of homogeneous gaseous mixtures, also read before the Institution of Civil Engineers, and for which he was awarded the Telford Premium. In 1887, he produced what he termed a flame injection engine, an engine which, though abandoned at the time, was revived in a modified form six years later by Dr. Diesel and has since become famous as the Diesel engine. In 1904, also, he delivered before the Institution of Civil Engineers the first James Forrest Lecture on the internal combustion engine; this was followed in 1907 by another very valuable paper on the limits of thermal efficiency in internal combustion engines, in which he showed, for the first time, that the loss of heat to the cylinder walls is by no means so serious as had previously been supposed. This paper was awarded the Telford Medal. In 1908 he was made a Fellow of the Royal Society, largely in consequence of his classic paper on the specific heat of the working fluid in internal combustion engines, read before that Society in 1906. From then on to the present day, he has made numerous investigations, and read many important papers defining the state of the art; and always pointing the way to further developments, probably the most notable of these being his Gustave Canet Lecture, before the Junior Institution of Engineers in 1913. During the period of the War, he worked indefatigably on numerous technical Committees, where his experience and advice proved invaluable. Among other appointments he held, was that of Director of Engineering Research to the Admiralty, 1916-1918. Included in the many honours conferred upon him, in addition to his Knight Commandership of the British Empire and Fellowship of the Royal Society, are those of D.Sc. of Manchester and of Leeds, and LL.D., both of St. Andrews and Glasgow.

While his scientific work has done more than that of any man living, to promote the development of the internal combustion engine, the charm and power of his personality have instilled enthusiasm into many of the younger generation, thus providing a host of disciples who ensure that this development will continue along the lines he has so ably laid down.

VIII.—Medals for Papers.

Nine medals have been awarded for the papers read before the Society during the present session—five for papers read at the Ordinary Meetings, one for those read in the Indian Section, one for those read in the Dominions and Colonies Section, and two for those read at Joint Meetings of the Indian and Dominions and Colonies Sections.

The awards are as follows:—

Papers read at the Ordinary Meetings:—

Howard Maurice Edmunds, "Photo-Sculpture."

Edward Victor Evans, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry."

W. A. Appleton, C.B.E., Secretary to the General Federation of Trade Unions, "The Proper Functions of Trade Unions."

John Francis Crowley, D.Sc., B.A., M.I.E.E., "The Use and Advantages of Electric Power in the Factory, as illustrated by its Application to the Jute Industry."

Lawrence Haward, M.A., Curator of the City Art Gallery, Manchester, "The Problem of Provincial Galleries and Art Museums, with special reference to Manchester."

Paper read in the Indian Section:—

Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India."

Paper read in the Dominions and Colonies Sections:—

Frederick Coate Wade, B.A., K.C., Agent-General for British Columbia, "British Columbia—The Awakening of the Pacific."

Papers read at Joint Meetings of the Indian and Dominions and Colonies Sections:—

Professor William Arthur Bone, D.Sc., Ph.D., F.R.S., "Lignites and Brown Coals and their Importance to the Empire."

PROFESSOR W. ECCLES, D.Sc., F.R.S., M.I.E.E., "Imperial Wireless Communication."

For many years it has been the practice that no medals should be awarded to members of the Council, or to readers of papers, who have previously received medals from the Society. Acting on this rule the Council were precluded from considering the following papers:—

MAJOR PERCY A. MACMAHON, R.A., LL.D., Sc.D., F.R.S., "The Design of Repeating Patterns for Decorative Work."

NOEL HEATON, B.Sc., "The Preservation of Stone," and "The Production of Titanium Oxide and its use as a Paint Material."

PROFESSOR A. P. LAURIE, M.A., D.Sc., F.R.S.E., H.R.S.A., "The late Mr. Holman Hunt's Experiments on the Permanency of Artists' Oil Colours."

PROFESSOR ERNEST R. MATTHEWS, "Coast Erosion and its Prevention."

GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland (Coal, Peat, Water Power)."

MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., "Tanganyika Territory (formerly German East Africa)."

ALFRED HENRY ASHBOLT, Agent-General for Tasmania, "An Imperial Airship Service."

The Council desire, however, to express their appreciation of these papers.

IX.—OWEN JONES PRIZES.

With the kind assistance of the Director of the Victoria and Albert Museum, the Council again in 1921 arranged for a competition of students from Schools of Art in accordance with the terms of the Owen Jones Trust.

The subjects of competition were:—

BOOK PRODUCTION AND ORNAMENTAL LEATHERWORK: including Covers and Lining Papers for Bookbinding, Title Pages, Lettering and Printing, Posters, Trade Labels and Advertisements.

METALWORK: including work in Precious Metals, Ironwork, Jewellery, Enamelling, etc.

WALLPAPERS, and other Mural Decorations.

TEXTILES: including Damasks, Brocades for Decoration and Furniture, Printed Fabrics for Hangings, Vestments and Church Fabrics (including Altar Frontals, etc.), Figured Velvets and Figured Muslins.

Two hundred-and-thirty-seven designs or works were submitted by 181 competitors from 36 schools. These figures show a marked increase as compared with those of 1920, when 94 designs were submitted by 63 competitors from 17 centres. The judges also reported a considerable advance in the standard of the candidates' work.

In accordance with the recommendation of the Judges the Special Prize of £20 was divided equally between H. S. Evans, School of Art and Design, Nottingham, and Miss E. Suthons, Municipal School of Art, West Bromwich; while, in view of the high standard of work as well as the large number of entries, seven ordinary prizes were awarded instead of the six originally offered by the Council.

The work was exhibited to the public at the Victoria and Albert Museum from July 21st to September 17th.

Full information of the conditions of the competition in 1922 were published in the *Journal* of January 6th last (p. 145).

X.—EXAMINATIONS.

The examinations form an important and rapidly growing branch of the Society's work. A number of large firms now encourage their employees to enter for them, and many of them grade their junior staffs according to the results of the examinations. This increasing recognition of their value is naturally having a marked effect on the number of entries. At the March-April examinations there were 22,160 entries, and at the May-June examinations 38,172 entries, making a total of 60,332, an increase of 5,136 over the corresponding figure for 1921. In order to show their growth the figures are given for the last four years, for 1914, which was then the record year, and also for 1916, which shows the effect of the war on the entries:—

Year.	Number of entries.
1914	37,974
1916	25,968
1919	34,173
1920	54,010
1921	55,182
1922	60,332

The following subjects were added to the Syllabus in 1922:—In Stage III., "Insurance Law and Practice" and "Railway Economics;" in Stage II., "History of Inland Transport in Great Britain." Papers

in "Commercial Law" and "Company Law" were also set in both Stages II. and III., instead of in Stage III. only, while papers in "Theory and Practice of Commerce" were set in all three stages instead of in Stages III. and II. only.

Two new Group Certificates for Shorthand Typists and Shipping Clerks were also instituted. Particulars of these are given in the syllabus of examinations.

The liberality of the Worshipful Company of Clothworkers has enabled the Council, as in past years, to offer the usual silver and bronze medals. These medals are very highly valued by the successful candidates, and they contribute not a little to maintain the high standard of the examinations.

The results of the First Division of the Examinations, held in March-April, have already been communicated to the candidates; and those of the May-June Division will be announced as soon as possible.

A report giving full details of the year's Examinations will be published in the *Journal*, as usual, at a later date.

XI.—Oral Examinations in Modern Languages.

The Oral Examinations are still in progress in various parts of the country. Particulars will be given in the annual report on the Examinations.

XII.—Peter Le Neve Foster Prize.

The Council decided to offer the Peter Le Neve Foster Prize of £10 and the Society's Silver Medal (founded in commemoration of Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1879) for an essay on "The Mineral Resources of China." An announcement to this effect was published in the *Journal*,* and December 31st, 1921, was fixed as the date by which entries were to be received. The essays were referred to an adjudicator appointed by the Council, and on his recommendation the prize was awarded to Mr. C. Y. Wang, Consulting Mining Engineer, of Hankow.

XIII.—New Council.

Mr. Alan A. Campbell Swinton has been nominated a Vice-President by His Royal Highness the President, in view of the special services which he has rendered to the Society by occupying the office of Chairman of the Council for four years and by the very great interest he has taken in initiating and promoting the fund for purchasing the freehold of the Society's House.

The Vice-Presidents retiring under the ordinary regulations are: Sir William H. Davison (who is nominated a Treasurer), Sir Robert A. Hadfield, Lord Leverhulme and Sir Aston Webb. In their places the Council recommend Lord Inchcape, Senator Marconi, Lord Montagu of Beaulieu, and Mr. John Slater.

The four Ordinary Members of the Council retiring are: Sir William H. Clark, Mr. John Slater (who is recommended as a Vice-President), Mr. Charles B. L. Tennyson and Professor J. M. Thomson. In their places the Council recommend Sir Dugald Clerk, Sir Thomas Holland, Sir Humphrey Leggett, and Sir Frank Warner.

XIV.—Obituary.

A number of distinguished Fellows have died during the last twelve months.

The Earl of Halsbury, who reached the great age of 98, was at one time a member of the Council and a Vice-President of the Society.

The Earl of Ducie, the "Father" of the House of Lords, also served on the Council and was a Vice-President of the Society.

The Right Hon. Frederick Huth Jackson was a director of the Bank of England and a high authority on Finance.

Sir Alexander Hargreaves Brown had been a member of the Society since 1871 and took considerable interest in its proceedings.

Sir William Edward Garforth, the well-known mining engineer, was awarded in 1911 by the Council a gold medal under the Fothergill Trust "in recognition of his efforts to perfect and secure the adoption of rescue apparatus in mines."

Sir Frederic W. R. Fryer was a member of the Indian Section Committee and a constant attendant at the meetings of the Indian Section, at which he frequently spoke.

Mr. T. N. Nacheapa Chetty was a well-known banker and philanthropist. At his death his son, Mr. T. N. Muthiah Chetty, contributed a sum of £500 to the fund for purchasing the Society's house.

Among other notable Fellows who have died during the year may be mentioned

*See *Journal*, April 1st, 1921, Vol. lxix., p. 220.

Sir Samuel Davidson, Sir George John Smith, Sir Edward Charing Wills, Mr. Ralph Brocklebank, Mr. Edward Hopkinson, M.P., the eminent engineer. Sir Henry Francis Barker, and Mr. W. J. Starr. The well known Russian metallographist, Professor Dimitris Tschernoff, who was elected an Honorary Corresponding Fellow of the Society in 1909, also died within the year.

Notices of the above named, and of other Fellows who have died during the last twelve months, will be found in the columns of the *Journal*.

XV.—Finance.

The income and expenditure account for 1920 showed a balance, being excess of income over expenditure of £548 15*s*. 2*d*. Unfortunately, the corresponding figure for 1921 showed an excess of expenditure over income of £405 15*s*. This deficiency is, to a large extent, due to the doubling of the *Journal* postage, which meant an additional expenditure of nearly £400. The annual subscriptions in 1921 amounted to £7,005, an increase of nearly £300 over the figure for 1920; but there was a very great decrease in the sum received for life composition fees. In 1920 this figure was £1,550—by far the largest amount ever received under this head; but in 1921, by which time the general depression throughout the country was making itself felt, it fell to £520.

The cost of the *Journal* fell from £4,541 in 1920 to £4,030 in 1921, and it is confidently expected that this sum will be similarly reduced again in 1922. It is also hoped to make further considerable reductions in the cost of printing in connexion with the Examinations. Last autumn the Council purchased a Gammeter Multigraph Printing Machine, at a cost of £355. With this it will be possible to print most economically a great deal of the stationery, etc., required for the Examinations, as well as much miscellaneous work, such as invitation cards for meetings, Council Agenda, etc.

Owing to the large increase in the number of candidates for the examinations, it was increasingly difficult to carry out the work of handling from 50,000 to 60,000 papers in the very limited space available in the Society's house. In September last an opportunity presented itself of leasing three suitable rooms at No. 18, John Street, and the Council decided to take them at a rental of £200 per annum. This amount will be met by the increased fees of candidates, while the room in the Society's house hitherto devoted to the Examination work, will be available as a smoking room for Fellows.

It has also to be borne in mind that, as the Society has now acquired the freehold of their house, the rent (£600 per annum) will be no longer payable. When all these points are taken into consideration, the Council hope to show a satisfactory income and expenditure account for 1922.

The Chairman (Mr. Alan A. Campbell Swinton, F.R.S.) moved the adoption of the Report. The most interesting matter in it he thought was that relating to the purchase of the building and the suggested improvements, and he would give them some idea of what it was proposed to do. So far as the meeting room was concerned, they hoped to make it more comfortable by removing the platform and raising the floor, and having a gangway in the centre at a higher level. The whole of the seats would be at a more or less uniform slope, and instead, as at present, of people in the front having to look up to the speaker, they would look down upon him. When experiments were shown at the meetings, it was very difficult to demonstrate them satisfactorily with the present arrangement of the platform. The Council also proposed to have new seats. They had visited several Institutions, and the seats they intended to adopt were based upon those in use at the Society of Antiquaries, which were of the Chippendale period. This form of seat would be slightly altered in order to make it still more comfortable. The meeting room was to be re-decorated and the ceiling painted white. The present electric chandeliers would be taken down and alabaster bowl reflectors used instead. The pictures would be cleaned and the portraits re-arranged, those of the first two Presidents of the Society being restored to their original places. The lower part of the walls, under the Barry pictures, would be painted a much lighter colour. Considerable alterations would also be made in the lower rooms and the entrance hall would be made more imposing. The staircase would end at the first floor, and a roof would be put in on a level with the present gallery, which would give them an additional room for storage purposes. The library would be restored to the condition it was in as built by the Brothers Adam. The present projecting cast iron cases, made for the reception of models, would be removed and supporting columns put in their place. This would make the library much larger and there would be additional light from the side windows, at present blocked by the cases. Cloak room and lavatory accommodation for ladies would also be provided.

These were the main changes. At present they could not afford to spend too much, but at a later stage they hoped it would be possible to re-decorate the Council Room and other rooms throughout the building. Another matter in the Report he wished to refer to was the paragraph relating to Sir Dugald Clerk, which was written by a disciple of his, one of our cleverest engineers and the designer of the engines used in the Tanks—Mr. H. Ricardo, to whom they were greatly indebted for the admirable account of Sir Dugald Clerk's work.

SIR PHILIP MAGNUS, BT., M.P., said he had very great pleasure in seconding the adoption of the Report. He agreed with the Chairman that one of the most interesting matters referred to in the Report was the fact that the Society had at length obtained possession of the building in which it had been housed for so many years. He felt sure the alterations it was proposed to make would be very much to the advantage of the Society and to the general body of Fellows. He was glad to hear that the seats in the meeting room would be similar to those at the Society of Antiquaries. The Report he said, gave an extremely good resumé of the excellent papers and lectures which had been given before the Society. The Report dealt with a great many matters of scientific and technological interest. The meetings had been well attended, and it was very satisfactory to notice that the papers had been followed by discussions in which experts thoroughly acquainted with the subjects had taken part. To anyone interested in the application of science to industry, he knew of nothing more educational than the *Journal* of the Society. Another subject in which he took a more distinct and particular interest, was the Examinations, the entires for which, as stated in the Report, had risen from 37,974 in 1914, to 60,332 in 1922. It was now close on fifty years since the Society first endeavoured to arouse interest in the application of science to industry and in the details of commerce, by encouraging instruction in its applications by means of examinations. It certainly was the first Society in this country to introduce what are known as technological examinations — examinations which dealt with applications of science to the applications of industrial concerns. These examinations were afterwards taken over by the City and Guilds of London Institute, and since that time the Society had extended its examinations in commercial subjects, and had succeeded in popularising commercial science all over the country, so that commerce was now regarded on exactly the same lines as other University subjects which qualify for a degree. The Examinations Committee, of which he had the honour to act as Chairman, were always considering means for enlarging the scope of the examinations, and he could assure the Fellows that they were constantly receiving applications for increasing the number of subjects.

The adoption of the Report was then agreed to.

THE CHAIRMAN proposed a cordial vote of thanks to Mr. G K. Menzies (the Secretary), Mr. S. Digby (the Secretary of the Indian and Dominions and Colonies Sections), Mr George Davenport (the Chief Clerk), Mr J. H. Buchanan (the Accountant and Examinations Officer), and to the other officers of the Society for their services during the year. As mentioned by the previous speaker, they had had some most excellent papers, and their hearty thanks were due to Mr. Menzies and to Mr Digby for obtaining these.

THE SECRETARY returned thanks for this expression of confidence in himself and in the other officers of the Society.

The ballot having remained open for half-an-hour, and the scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. [The names in *italics* are those of Fellows who have not, during the past year, filled the office to which they have been elected.]

PRESIDENT.

H.R.H The Duke of Connaught and Strathearn, K.G.

VICE-PRESIDENTS.

Lord Askwith, K.C.B., D.C.L.
Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.
Lord Bearsted
Sir George T. Beilby, LL.D., F.R.S.
Sir Thomas Jewell Bennett, C.I.E., M.P.
Lord Blyth.
Edward Dent, M.A
Peter MacIntyre Evans, M.A., LL.D
*Field-Marshal Earl Haig, K.T., G.C.B., O.M., G.C.V.O., K.C.I.E.
Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E.
Sir Herbert Jackson, K.B.E., F.R.S
Senator Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
Brig.-Gen. Lord Montagu of Beaulieu, K.C.I.E., C.S.I.
Viscount Northcliffe.
Major Sir Francis Grant Ogilvie, C.B., LL.D.
Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.
Lord Sanderson, G.C.B., K.C.M.G.
John Slater, F.R.I.B.A.
James Swinburne, F.R.S.
**Alan A. Campbell Swinton*, F.R.S.
Carmichael Thomas
Sir Philip Watts, K.C.B., LL.D., F.R.S.
*Sir Henry Trueman Wood, M.A.

ORDINARY MEMBERS OF COUNCIL.

Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S.
Charles Frederick Cross, F.R.S.

*Nominated by H.R.H. the President.

Professor John Bretland Farmer, M.A., D.Sc., F.R.S.
John Somerville Highfield, M.Inst.C.E., M.I.E.E.
Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.
Major Sir Humphrey Leggett, D.S.O., R.E.
Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S.
Sir Philip Magnus, Bt., M.P.
Ernest H. Pooley, M.A., LL.B.
Sir George Sutton, Bt.
Sir Frank Warner, K.B.E
Sir Alfred Yarrow, Bt., M.Inst C.E.

TREASURERS.

Sir William Henry Davison, K.B.E., D.L., M P.
William Henry Maw, LL.D., M.Inst.C.E.

SECRETARY.

George Kenneth Menzies, M.A.

On the motion of the CHAIRMAN a vote of thanks to the Scrutineers was carried unanimously.

MR. CARMICHAEL THOMAS proposed a very hearty vote of thanks to the Chairman, and was sorry that this was the last occasion on which he would act as Chairman of the Council. He had held the office for four years, and during the past century there had only been three similar cases of double re-elections. It was a source of great regret to the Council that they now had to lose Mr Campbell Swinton as Chairman, and he felt sure all would agree that he deserved a very hearty vote of thanks for his valuable services.

MR. JOHN SLATER, F.R.I.B.A., seconded the motion. Mr. Campbell Swinton, he said, although a very busy man, had done an enormous amount of work for the Society, and they owed him their very cordial thanks for his services as Chairman, and for all that he had done in connection with the fund for purchasing the Society's House.

THE CHAIRMAN said it had been a great pleasure to him to act as Chairman of one of the most charming of Councils. He was also glad to be of assistance in raising funds to purchase the freehold of their historic house. He would like to point out though that the thanks of the Society were also due to Mr. Menzies for finding them their anonymous benefactor. This was the last time he would act as Chairman of the Council, and it would also be the last time they would meet in the room in its present condition. The renovation would be completed by November, when he hoped the room would have a more attractive appearance.

The meeting then adjourned.

BRISTLE TRADE OF TIENTSIN.

Bristles constitute one of the leading items of export from Tientsin. According to the Chinese maritime customs returns, the exportation of bristles from Tientsin in 1919 amounted to 2,300,667 pounds, valued at 1,912,972 haikwan taels, and in 1920 to 2,515,733 pounds, valued at 2,305,850 haikwan taels. The conversion of these tael values into foreign currency is likely to be misleading, because of the violent fluctuations in exchange in the years 1919 and 1920. The rate used by the Chinese Maritime Customs in actual entries varies week by week. For this reason the best index of the volume of the business is to be found in quantities rather than in values.

The bulk of the bristles from Tientsin go to the United States, but England, France and Japan share a portion of the trade.

Hotou, at the terminus of the East Canal, is a large distributing centre of bristles in North China Here bristles are brought from Tsunhua, Yungping, regions outside the Great Wall, and Manchuria, and after being sorted and graded are sent to Tienstin by junk or railway. Paotingfu and Peking are other large bristle centres, whence shipment is made to Tientsin, either by railway or from Paotingfu by river It is believed that the Paoting article is slightly inferior in quality to the Hotou bristles

From a report by the United States Consul at Dairen, it appears that there are several ways of working the bristle business for export from Tientsin. The principal amount is exported in assortments of 55 or 66 cases, but other assortments containing 80, 40, or 100 cases are sometimes made to meet special demands Of these usual assortments, the 55-case is considered the most desirable, because it contains a greater amount of long-length bristles. One of the usual type of 55-case assortments contains about the same number of cases of bristles of each length from 2¼ inches to 5½ inches. The bristles are packed in cases of 110 pounds net, including the weight of string used in tying the bundles, and all the bristles in a given case are the same length, but in an assortment the lengths vary usually by ¼-inch steps—for instance, 2½ inches, 2¾ inches, 3 inches and upward. The preceding remarks regarding the variation in length and packing apply to all assortments.

The 66-case assortment usually sells for a much lower price than the 55, averaging perhaps about 40 to 50 per cent. of the price obtained for the 55. This is due to the fact that the 66-case assortment contains a large number of cases of short lengths, principally 2½ inches long, and lesser amounts of the extra long bristles. It is generally understood that the greater the length, the higher the price. The basis of sale of an assortment is usually an average price per pound for the entire net weight of bristles in that assortment. Bristles are purchased

rom the producers in piculs (1 picul = 133 pounds) and sold to dealers abroad by pounds.

It is customary to grade the bristles according to elasticity, stiffness, colour, cleanliness and solidity. Of the bristles exported from Tientsin, the best quality comes from Mukden. As a rule, these are much more stiff and elastic, thicker, with less taper of individual hair, and of much blacker colour. After these come the Peking and Paotingfu quality, which, as a rule, are not so stiff, and have more taper of individual hair. The Paotingfu bristles are generally considered somewhat inferior to the Peking, but as Peking is a better known place and is a collecting centre for this commodity, it frequently happens that the Paotingfu dealers take their cargo to Peking and sell it as Peking quality, with or without mixing with actual Peking bristles.

The best quality of black Tientsin bristles is made by either selling straight Mukden bristles or by blending suitable proportions of Mukden with Peking or Paotingfu. A fair amount of Mukden bristles when mixed in with the Peking or Paotingfu quality adds materially to the general stiffness, appearance, and elasticity of the bristles bundled as a whole.

Bristles from Shantung Province are also exported from Tientsin. One of the principal sources of supply for the Shantung bristles is in the vicinity of Weihsien, and Shantung bristles brought to Tientsin frequently come from this region. The principal point of export, however, for Shantung bristles, is Tsingtau. Comparison of the Shantung (Weihsien) bristles with the Peking or Mukden quality will show that the Shantung are considerably finer with more taper of individual hair, are softer, and of poorer colour, and as a result of these characteristics the Shantung bristles bring lower prices than the northern grades.

There are several methods of securing bristles properly packed in assortments for export, including :—

(1) The purchase of complete, fully dressed, ready-packed assortments from regular Chinese bristle contractors, or from the compradore of the firm. As a rule, the quality of this cargo is guaranteed by the seller to the buyer.

(2) Partial assortments of ready-dressed cargo may be bought from dealers, and the firm may buy a few cases here and there of ready-dressed cargo of odd lengths to complete the assortment.

(3) The firm may buy a portion of an assortment in the form of ready-dressed cargo, and make up the balance from raw, unworked, loose bristles dressed in its own godown under direct supervision of its own staff or by contract with native bristle dealers.

(4) The firm may buy raw, loose bristles in bulk unsorted and work these by contract with professional bristle dealers who guarantee to supply the labour and to dress according to an agreed standard. If the firm is dealing with a reliable Chinese bristle contractor, this is possibly the better method than for a firm to dress the raw bristles in its own godown under the direction of its own staff.

Raw cargo for dressing may be secured from local Tientsin dealers or by sending men to the principal collecting centres, such as Mukden, Peking or Paotingfu, or to other interior sources of supply. The firm or the comprador will send out Chinese buyers who arrange the purchases, generally by giving cash advances to the bristle dealers. Some of the Tientsin firms have agents continually resident in the principal bristle centres. These men are always on the outlook for good offerings, and buy a few thousand taels worth of this lot or that lot, as cargo of suitable quality comes to hand. The goods so purchased are then forwarded to the main dressing station, which generally is in Tientsin or its vicinity.

The customary way of buying bristles from regular bristle contractors is to pay the latter a certain amount of advance money, usually 40 to 50 per cent. of the contracted amount. However, many firms, especially those dealing principally in bristles, purchase raw materials direct from interior points through their own agents, and the amount of money required for such interior purchasing depends, of course, upon the extent of the business.

CONDITIONS IN NORTHERN AND CENTRAL PATAGONIA.

The great stretch of territory here designated as northern and central Patagonia comprises the Territories of Rio Negro and Chubut, a part of the Territory of Neuquen, and the greater part of the Territory of Santa Cruz. It contains about 270,000 square miles. The population, however, is not over 100,000, or about one person per 3 square miles, and as most of the inhabitants are found in the coastal towns, the density of population in the interior is less than one person per 10 square miles. With the exception of the valleys along the slopes of the Cordillera, the entire region is a desert sparsely covered with bush and grass, which is unsuitable for cattle raising. Much of the soil is rich ; but, owing to the fierce winds and the lack of rainfall, agriculture generally is impracticable. Sheep raising —principally for wool— constitutes the chief industry of this vast region.

It appears from a report by the United States Trade Commissioner at Buenos Aires, that fully half of the total Patagonian population lives in the valleys of the Rio Colorado and the Rio Negro in the extreme north. The northern district has the advantage of railway connection with Bahia Blanca and Buenos Aires, and is, consequently, more developed than the southern part. Considering the size of the territory, railway communications are very inadequate. A branch of the Buenos Aires Great Southern Railway runs from Bahia

Blanca westward through the valleys of the Rio Negro and the Rio Colorado to Zapala, a few miles beyond Neuquen, and a short spur of the Buenos Aires Pacific connects Carmen de Patagones with Bahia Blanca. thus providing northern Patagonia with fair railway facilities. South of these the San Antonio-Barilloche Railway, one of the wide-gauge State railways, penetrates westward 281 miles into the Patagonian sheep lands. Another of the wide-gauge State railways, the Patagonian Railway, extends 124 miles westward from the port of Rivadavia to Colonia Sarmiento, crossing one of the most desolate parts of Patagonia. A metre-gauge line of about 50 miles, owned by an English company, and known as the Central Railway of Chubut, connects the port of Madryn with the lower valley of the River Chubut Most of these railways run parallel to each other, and up to the present no connecting lines have been built.

Lacking adequate rail communications, Patagonia necessarily must depend to a great extent on shipping, and two lines of coasting steamers maintain three boats each in the service between Patagonian ports and Buenos Aires. The chief ports along the 1,000 miles of coast line, extending from the Rio Negro to the Rio Santa Cruz, are Puerto Madryn, Puerto Deseado, San Antonio, Santa Cruz, and Comodoro Rivadavia. Puerto Madryn has an excellent deep sea harbour, where a few ships put in to discharge cargo for distribution to other Patagonian coast towns; but there is very little intercourse with oversea ports, and most of the business is done with Buenos Aires.

The vegetation of the central and northern Patagonian pampas (high plains) and cañadas (dry valleys) is so sparse that the maximum number of sheep it will support is said to be only a little over 100 per square mile, and much of it will not feed 50 per square mile. It is, therefore, necessary for the small sheep owner to hold at least 50 square miles of land, and the average holding of about 700 ranchmen in this region is officially stated as approximately 65 square miles. The total number of sheep in the district is about 9,000,000, and it is estimated that there are nearly 2,000,000 guanacos, or Patagonian llamas, ranging wild over this area. Sheep intended for meat are driven in flocks either northward to the railway in the valley of the Rio Negro or southward to the meat packing plants in Santa Cruz.

Cattle raising is carried on in the grassy valleys along the slopes of the Patagonian Andes. The young steers, in lots of 1,000, are driven northward along the mountain slopes to the railhead at Zapala, whence they are sent by rail to ranches in the Province of Buenos Aires. The journey to Zapala often takes 30 days. Thirty-four thousand head of cattle, and 83,000 sheep were loaded at Zapala during the summer of 1920.

Agriculture is possible only on a limited scale in this territory. The general difficulty in obtaining sufficient water and the fierce winds and sand storms, which necessitate the construction of costly windbreaks, bar agricultural development on an appreciable scale. Many settlers have been attracted to the upper valley of the Rio Negro, where an extensive irrigation system is under construction, and many fine vineyards, orchards, and apiaries are found near the towns of Allen and General Roca. The cultivable land, however, is limited to a narrow strip of flat valley along the river. Under great difficulties, the Chubut Valley has also been put under irrigation, and some dairying is carried on. A considerable amount of cheese is exported from this district to Buenos Aires. Trelew, a town of about 3,000 population, is the centre of a Welsh colony founded about 50 years ago. It is connected by rail with Puerto Madryn. A colony has also been established by a party of South African Boers a few miles north of Comodoro Rivadavia, and various small mixed colonies are found in the interior and along the eastern slopes of the Andes.

Until a foreign market opens up for Patagonian wool and sheep skins, there is no hope of doing business on an extensive scale with this region, as the price of wool in Buenos Aires covers little more than the freight from the ranches. Business conditions may be said to be fair only about the town of Comodoro Rivadavia, an important factor of this comparative prosperity being, of course, the exploitation of the Government oil fields near that port.

Under normal conditions, there is a market for motor cars, as the cart roads extending all over Patagonia are in fairly good condition, but the prevailing lack of ready money has completely stopped the sale of automobiles in that country. The market for hardware, wire fencing and other ranch needs has declined for the same reason. In normal times also Patagonia imports proportionally large quantities of tinned goods, and a considerable amount of the ordinary luxuries of life. A return to normal imports or better commercial conditions, however, cannot be expected until there is a world market for Patagonian pastoral products.

GENERAL NOTE.

ROAD DEVELOPMENT IN SZECHUEN.—The newly created Bureau of Roads of Szechuen Province, has recently announced its plans to build 2,000 miles of roads within the Province. The first road, writes the United States Vice-Consul at Chungking, will run between Chungking and Chengtu, a distance of 300 miles. The roads will be macadamized and are intended for motor traffic. The work, which was to have started in March last, is under the supervision of a foreign highway construction engineer.

Journal of the Royal Society of Arts.

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FRIDAY, JULY 14, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W C (2

FUND FOR PURCHASING THE SOCIETY'S HOUSE.

FIFTH LIST.*

	£	s.	d.
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The above list includes all subscriptions received up to July 10th. Further lists will be published in the *Journal* from time to time.

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will enable them to renovate and decorate the House and make it more attractive and convenient.

*The four former lists were published in the *Journals* of December 2nd, 1921, January 13th, February 24th, and May 5th, 1922.

NOTICE.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Friday, July 7th. Present:—Sir Charles S. Bayley, G.C.I.E., K.C.S.I., in the chair: Sir Charles H. Armstrong, Sir George C. Buchanan, K.C.I.E., M.Inst.C.E., Sir Krishna G. Gupta, K.C.S.I., Sir Charles C. McLeod, Lieut.-Colonel Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., Mr. Thomas McMorran, Mr. F. Noyce, I.C.S. (Indian Trade Commissioner), Mr. N. C. Sen, O.B.E., and Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., M.P., with Mr. G. K. Menzies (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

PROCEEDINGS OF THE SOCIETY.

TWENTY-THIRD ORDINARY MEETING.

WEDNESDAY, 24TH MAY, 1922.

SIR GEORGE BEILBY, F.R.S., in the chair.

The CHAIRMAN said the reader of the paper had just recovered from a long and very serious illness, and it was a matter of great surprise that he had been able to come to London, against the advice of his friends, to read his paper. He was sure the author would be accorded an extra welcome on that account.

About 21 years ago, Mr Fletcher went to Ireland as Senior Inspector of Technical Education, during Sir Horace Plunkett's regime as Vice-President of the Department of Agriculture and Technical Instruction for Ireland. Subsequently, in 1904, he became Assistant Secretary to the Department in respect of Technical Education, to which latter post he succeeded on Sir Robert Blair's appointment as Education Officer to the L.C.C. Mr. Fletcher had carried on the onerous task of administering technical education in Ireland with patience and tact for the past 20 years, and in that work had won the goodwill of the many divers bodies with whom

he had had to deal. He was one of the Members of a Committee set up by the Government in 1918 to report on the Co-ordination of Primary, Secondary and Technical Education in Ireland. In 1917 and 1918, he served as a member of the Irish Peat Enquiry Committee, to whose labours he contributed with considerable energy. In many of his papers and lectures dealing with the industrial resources of Ireland, he had given much attention to advancing the claims for the utilisation of peat, with the recovery of by-products for the generation of power on a large scale for use in industry. During 1919, the author acted as a Member of the Irish Water Power Resources Sub-Committee, of which Sir John Purser Griffith was Chairman, and he had thrown himself with great energy into the study of the methods by which the undeveloped industrial resources of Ireland might be made available for the Irish people.

The paper read was :—

THE POWER RESOURCES OF IRELAND.

(Coal, Peat and Water Power).

By George Fletcher, F.G.S., M.R.I.A.

It is only during the last few years that the Fuel resources of Ireland have been made the subject of systematic enquiry. I include under the term "Fuel Resources" Water Power, *la Houille Verte*—as such low head falls as we shall deal with, have come to be called in France. It is necessary to qualify this generalisation. Our knowledge of coal reserves has been enriched by the work of the Geological Survey, while in the matter of peat we owe a debt of gratitude to the valuable report of the Bogs Commission which appeared over a century ago (1809-1814). This report however, valuable as it is, was written something like a quarter of a century before Faraday's experimental researches on electro-magnetic induction were made and three-quarters of a century before the electrical transmission of energy became a *fait accompli*. The main object of the Commission then was not peat-winning but land-reclamation. The Report suffered the common lot of expert reports. No action was taken on it, and it was well-nigh forgotten.

It needed the stimulus afforded by a great European war to provoke enquiry into the Fuel Resources of Ireland. These had, it is true, been studied by a number of individual enquirers, first among whom must be counted Sir Robert Kane, whose "Industrial Resources of Ireland" appeared in 1844, but nothing definite or authoritative was available to the public, whose views on the subject of coal, peat and water power, were of necessity extremely vague. There was, however, a widespread demand for authoritative enquiry. The Department of Agriculture and Technical Instruction for Ireland, early in 1917, invited the attention of the Advisory Council of the Department of Scientific and Industrial Research to the question of the utilisation of our peat deposits, and the matter was referred to the Fuel Research Board, with the result that an Irish Committee of Inquiry was appointed with Sir John Griffith as Chairman on July 2nd, and reported on February 26th, 1918, and, after a conference with the Fuel Research Board, rendered a Supplementary Report on July 10th, 1918.

The necessity for collating our knowledge respecting our coal reserves led to the appointment in 1919 of the Irish Coal Industry Committee, while a fuller enquiry was subsequently initiated by Dail Eireann by the appointment of a Commission of Inquiry into the Resources and Industries of Ireland the Power Committee of which have already (1920) issued a *Memoir* on our coal resources, while reports on coal, peat and water power are promised.

In regard to water power, while a large amount of information had been accumulated —mainly as a result of several Royal Commissions and Expert Reports—such information related to navigation and drainage rather than to water power, and though a good deal of information had been obtained through the operations of the Board of Works, there was pressing need for a comprehensive enquiry into our rivers from the point of view of Power, and after the appointment of a Committee to examine and report upon the water power resources of the United Kingdom, the Board of Trade appointed (November 29th, 1918) a Sub-Committee, with Sir John Griffith as Chairman, to report upon the subject so far as it affects Ireland. This Committee reported on December 6th, 1920.

Having thus briefly indicated the main sources of the latest information and opinion on these different but interrelated problems I propose, as far as is possible within the limits of a single paper, to summarise the state of our knowledge and to discuss its bearings from the economic standpoint.

COAL.

In the matter of coal deposits geological processes have treated Ireland unkindly. The great central plain consists of lower carboniferous strata, and this was doubtless covered by coal-bearing strata. The area was then disturbed and folded by the Armorican earth movements, and subsequently subjected to prolonged denudation which stripped off these upper carboniferous coal-bearing strata, leaving only a few isolated deposits, which together occupy an area of somewhat more than 110 square miles. The largest of these forms the Leinster Coalfield (an area of 94 square miles) with the mines of Castlecomer on the west side of the field and the Wolfhill Collieries on the east side, both yielding a good quality of anthracite. To the south-west is the small coal area of Slieve Ardagh also yielding anthracite. The proved reserves of these fields amount to 172 millions of tons, that is, something like nine-tenths of the total proved coal reserves of Ireland. The remaining coalfields in Co. Tyrone (Coalisland, Dungannon and Annaghone) at Ballycastle and Lough Allen (Arigna and Slieve-an-Ierin) are semi-bituminous in character. It is possible that additional coal may be found in the Lough Neagh (County Tyrone) area, for the coal measures here dip eastward under the Triassic sandstones—one of the seams here is 9ft. in thickness. The large area of upper carboniferous strata in the counties of Limerick and Clare yield a few occasional seams of anthracite, but for various reasons it has not hitherto been found profitable to develop these measures.

It will be useful to set out the estimates of Irish coal reserves as arrived at by the Irish Coal Industry Committee and the Irish Commission of Inquiry. They are as follows:—

The striking disparity between these two estimates, made within a year or so of each other, calls for explanation—one makes no reference to the Munster Coalfield, which has not been worked for a century, while the other estimates its reserves at 1,570 millions of tons.

The *Memoir* issued by the Commission of Inquiry gives reasons for the inclusion of areas and coals hitherto regarded as uneconomic, arguing that economic conditions are not fixed and unvarying and that a coal which might not be "economic" at one time might become so under other conditions. It was considered better, therefore, to give a full and detailed statement of all reserves. The sliding scale of Economic Conditions could then be adjusted from time to time to this comprehensive statement. In regard to the extensive Munster coalfield it points out that, while it has been neglected in estimating the national coal resources, the *Middle Coal Measures* of this area contain at least six coals, some of which reach thicknesses of 5 and 7 feet, occasionally bulking to double these thicknesses, most of them good quality anthracite. The district is somewhat remote from large industrial centres, offering considerable transport difficulties, and in no part of it has any work been conducted for nearly a century.

This resumé of Ireland's coal resources, compiled on the basis indicated, will be of great value if certain conditions and limitations are understood. It is not possible accurately to forecast economic changes and it is of importance to develop our coal resources as far as possible. A cheerful economist—I think it was Dean Swift—remarked that we should "burn everything English except their coal," and it is clearly

	Commission of Inquiry.	Coal Industry Committee.	
		Actual Reserves.	Probable Reserves.
	Tons.	Metric Tons.	Metric Tons
Leinster Coalfield ..	299,000,000	156,730,000	—
Slieve Ardagh Coalfield	40,000,000	15,080,000	—
Munster Coalfield ..	1,570,000,000	—	—
Connacht Coalfield ..	29,000,000	8,696,000	—
Ballycastle Coalfield ..	49,000,000	—	13,720,000
Coalisland Coalfield ..	40,000,000	—	31,210,000
Annaghone Coalfield ..	17,000,000	—	3,000,000
Total	2,044,000,000	180,506,000	47,930,000

undesirable that Irish industries should be at the mercy of a fuel supply wholly outside their control. It is this which renders the question of power resources a vital one for Ireland. It is a significant fact that Ireland does not raise more than one-fiftieth of the coal consumed in Ireland and it does not appear that under existing economic conditions she can replace her coal imports by native coal alone. It does not follow that she need continue to import 4½ million tons of English coal. It appears highly probable, indeed, that she can with great advantage to herself replace the greater portion of this by increasing the output of her own mines, and by utilising more fully her splendid peat deposits and water power.

It is, however, important to remember that under existing economic conditions, Irish coal must be raised in competition with imported coal and in competition with other fuels. It seems very probable that long before the existing Irish mines are exhausted Irish peat will have proved itself a serious economic rival. It must not be forgotten that the tendency is for the cost of winning coal to increase progressively as the depth and distance of working faces from shafts increase. This disadvantage, common to all coal-mining operations, is aggravated in Ireland by the thinness of the seams and the consequent necessity to remove great quantities of waste material in order to win the coal. This accounts in large measure for the fact that while in Great Britain the annual output per underground worker is 294 tons, it is, in Ireland, only 149 tons. As the miner is paid by the amount raised by him the wages of the Irish worker are less than those of his British *confrère*. To these disabilities must be added that of inadequate transport. Prior to the war the existing collieries were not on or even near a railway. During the war a railway 10 miles in length has been built connecting the Castlecomer Collieries with the existing line at Dunmore, near Kilkenny. Another, also 10 miles in length, was built to connect the Colliery at Wolfhill with Athy, while a short line now connects Arigna with the mines. This improved transport, together with improved methods of winning should lead to an increased output for home consumption. The annual output of Irish coal may be taken as about 90,000 tons or about one-fiftieth of the amount imported—4,500,000 tons. The amount of coal raised in Ireland in the year 1854 was 148,750 tons, and the output has declined pretty consistently ever since. The Irish Coal Industry Committee expressed the view that "with reasonable transport and housing facilities" the output might be increased to 500,000 tons. While every effort should be made to increase the output and to increase the efficiency of winning the coal, it will be evident that, in view of the facts I have stated, peculiar economic importance attaches to our other fuel resources. Before dealing with these it will be convenient to state Ireland's annual consumption of fuel. It is as follows:—

	Tons.
Coal (imported) ..	4,500,000
Coal (mined in Ireland ..	90,000
Peat (won in Ireland) ..	7,000,000

Taking the Peat as having a calorific value half that of coal our total fuel consumption may be taken to equal approximately 8,090,000 tons of coal. Little more than a quarter of the imported coal gets inland beyond the large coastal towns. Somewhat over two million tons is used for domestic purposes and a little less than than 1½ million tons is used for Industrial purposes, the remainder being consumed by Railways and by Gas and Electricity works. The domestic fuel of the great mass of the people is hand-cut turf or peat.

PEAT.

In spite of the fact that some seven millions of tons of air-dried peat are consumed annually by domestic hearths in Ireland, our reserves of this fuel are enormous It is estimated that our bogs contain no less a quantity of peat than 4,000 million tons—reckoned as "air dried" (25% moisture) an amount sufficient to meet our present fuel requirements for all purposes for something like 200 years.

It will be convenient to distingush between two principal types of bog, viz.: (1) the scattered mountain bogs, the cutting of which with the "slane" yields the main source of fuel to the rural population of Ireland; probably a million and a half of the people depend solely on peat for domestic uses, and (2) the great flat bogs which overlie so much of the great central plain. These great tracts of flat and deep bogs contain nearly 2,000 million tons of peat calculated as anhydrous.

Nearly three-fourths of this lies within a "central belt" bounded on the north by a line joining Howth with Sligo and on the south by a line joining Wicklow with Galway. While the mountain bogs are being cut away and used as domestic fuel, the large flat bogs have scarcely been utilised, and though their margins have been cut for domestic purposes their outline has scarcely been modified since the survey of the Bogs Commission over a century ago. Their utilisation presents a most interesting economic problem which, until the last year or two, has received far less attention than it deserves. Of speculation and individual adventure, with expenditure of large sums of money, there has been plenty, and many distressing failures might have been avoided if the truth of the First Law of Thermodynamics and certain economic principles had been recognised and applied. The chemical and physical properties of peat offer a perplexing problem to those who seek to utilise this great natural resource and the problem will only be solved by scientific experiment and a recognition of economic principles. Permit me briefly to describe these properties in so far as they are relevant to economic development.

The salient fact about peat as it occurs in nature is its extreme and ineradicable wetness. An undrained bog may be assumed to contain from 90 to 95 per cent. of water. Efficient draining may reduce this to between 91 and 88 per cent. Thus, in a bog containing 90 per cent. of water, the small farmer, in order to win his year's supply of turf, which may be taken to average 25 tons when air-dried to 25 per cent. moisture (spoken of hereafter simply as "air-dried") must cut and spread no less than 188 tons of raw peat. Indeed, if allowance be made for losses in dust and "smalls" necessarily left behind on the bog, the amount to be raised must be over 200 tons of raw peat. In spite of the labour involved, this fuel is of enormous value to the population of the south and west. In the Province of Connaught, for example, the annual consumption of coal per head of population amounts to less than one-fifth of a ton. It is necessary to conserve this fuel for the use of rural-dwellers. In certain densely populated districts occupied by small land owners, it is possible that, owing to the exhaustion of the small local turbaries, it may be necessary to migrate families unless provision can be made for the supply of fuel from a distance. This consideration brings me to the second defect of peat as a fuel. The average calorific value of "air dried" peat lies between 6,000 and 7,000 B.Th.U. per pound. That of coal as supplied in Dublin is from 11,000 to 12,000 B.Th.U. per pound. Taking the mean of these figures, the calorific ratio of coal to peat will be as 1.77 to 1 or, put differently, 1.77 tons of peat will be required to give the same amount of heat as one ton of coal. This quantity of peat will, when loaded, occupy from 3½ to 5½ times the space occupied by one ton of coal. This bulkiness of peat combined with its friability offers transport difficulties which militate against its use at a distance from the bog, though it is necessarily carried by road and canal. About 6,500 tons of peat is brought yearly from the Bog of Allen by the Grand Canal to Dublin, and used for domestic purposes, while a good deal is carried along the coast of Connemara in the small sailing boats known as "hookers." For many years past efforts have been made to overcome these defects. Attempts were made to express the water by compressing the peat, but the manner in which the water is retained by the vegetable fibres renders this impracticable. The maximum effect produced by pressure is to reduce the water content from 90 per cent. to 70 per cent. It was then sought to break up the fibre, in some cases by maceration, in others by treating the peat with super-heated steam or high tension electricity or by admixture with some mineral substance such as lime. The fibre can, no doubt, be broken up, and the expulsion of the water by pressure thus rendered possible, but the Irish Peat Enquiry Committee reported that, so far as they knew, "no successful process exists for eliminating the excess water contained in peat other than natural air-drying."

It would be outside the scope of this lecture to deal with these various experiments, but I must refer to the very interesting work recently done in maceration at Turraun, because of the practical bearing of the results obtained. The process of maceration is accomplished by feeding raw peat into a machine which has usually an arrangement of fixed and rotating knives arranged spirally in such a manner that the vegetable fibre in the peat is cut or torn and the whole mixed up and pressed out

in a continuous band through a mouthpiece of suitable shape. This pulp-like band of macerated peat is cut into sods and spread on the drying ground. The effects of maceration may be summarised as follows:—

(1) Since the light spongy peat from the surface and the more dense black peat from the bottom of the bog can be thoroughly mixed a more uniform product is secured.

(2) The macerated peat dries much more quickly than non-macerated peat, and in a few days a surface film is produced which in a large measure protects the sod from rain.

(3) The resulting sods are much more compact, having a higher density than those resulting from unmacerated peat. While a ton of unmacerated slane-cut peat fuel occupies approximately 140 cubic feet, a ton of the macerated product occupies only 100 cubic feet—instead of occupying 5½ times the space which would be occupied by its calorific equivalent of coal it only occupies four times this space.

(4) The improved density and texture of macerated peat enables it to be "footed" and harvested with slight loss from dust and smalls, its transit qualities are enormously improved and it is rendered much more suitable for producer plant and gas retorts. Its use in the latter is under experiment by the Fuel Research Board at their Research Station at East Greenwich, and a report on "The Carbonisation of Peat in Vertical Gas Retorts" has been issued.

There is no reason to doubt that maceration will play an important part in peat utilisation in Ireland. It will secure a fuel supply to those districts where the small local bogs are exhausted. It may also find an extended use for industrial purposes, but it is impossible to avoid the conclusion that, for such purposes, a fuel of this character should, *in situ*, be converted into energy which might be either transmitted electrically to industrial centres or employed for electro-chemical industries in the neighbourhood.

The Irish Peat Inquiry Committee made a series of recommendations in this sense. Their first task was to arrive at a rating for peat. Working on pre-war labour rates they found that in the case of the bog at Ticknevin, Co. Kildare, the actual cost of winning and "clamping" on the bog was 2.76 shillings per ton air-dried. The total cost of winning and stacking the peat on the canal bank 1½ miles away was 5.96 shillings per ton. This would enable peat to compete with coal at this point. The calculations were based upon a wage of 12s. per week of 72 hours. It is hardly necessary to point out that a great change has taken place, and that it is highly improbable that such conditions will recur. There would be little advantage under present conditions in endeavouring to bring these ratings up to date.

The Committee recommended the State purchase of a large bog and the initiation of experiments on a large scale, including systematic drainage and reclamation of the bog so as to fit it for cultivation and ultimate use for peat-winning. Different types of peat-winning machines were to be employed for comparative tests. It was proposed to instal gas producers in which peat was to be used, and the by-products recovered, the power to be employed in producing electric power for distribution, etc.

The Fuel Research Board, after a careful consideration of the report, held a conference with the Committee, as a result of which it submitted a supplementary report dated July 10th, 1918. This report was accompanied by estimates and involved a less extensive scheme than that which had been proposed, but adequate to the demand for experimental enquiry. The Fuel Research Board concurred generally in these recommendations, remarking that "The Board are of opinion that if satisfactory arrangements can be made for the purchase and holding of a selected bog area, and for the management of an agricultural colony on that area, then the (above) expenditure on the establishment and running of an experimental station would be justified; for the results obtained ought once for all to clear away the uncertainty which has hitherto prevailed as to the economic possibilities of the bogs of Ireland." It should be pointed out that the proposed experiments involved machine digging with air-drying. The operations concerned with the latter are seasonal and hence it becomes necessary to find for the families engaged in the work some auxiliary employment. and this it was proposed to find in the reclamation and cultivation of the bog surface and also of the cut-away surface. Such an association of the agricultural and fuel industries is common in Canada, the United States and European countries, and in many

places in Ireland excellent crops are to be found growing both on the virgin-bog and on the cut-away bog.

The recommendations of the Committee have not yet been carried out. It is not my purpose to discuss the reasons for this, but so great is the economic importance of the matter, and so widely is this recognised, as is shown by the creation of a Commission to enquire further into it (among other cognate questions) that I feel satisfied it will shortly be dealt with effectively by an Irish Government. It must not be supposed, however, that no work had been done on the subject subsequent to the issue of the Committee's reports. The Fuel Research Board, in addition to the work carried out in their experimental station at East Greenwich, have been collecting information from abroad, and my friend, Professor Purcell, of University College, Dublin, has, in connexion with the Board, extended the valuable work he did as Secretary of the Irish Peat Inquiry Committee. His lecture on "The Peat Resources of Ireland," is a valuable contribution to the subject, while his colleague, Professor Ryan, has laid us under an obligation by his translation of Hausding's *Handbuch der Torfgewinnung und Torfverwertung.* Both have been published by the Fuel Research Board.

WATER POWER.

The causes which led to the creation of a Water Power Resources Committee by the Board of Trade led to the appointment of an Irish Sub-Committee on June 20th, 1918. The Sub-Committee were fortunate in having as its Chairman Sir John Griffith, who had also been Chairman of the Irish Peat Inquiry Committee, and whose long engineering experience and mature judgment were an invaluable asset.

It will not be useless to enquire at this point the reasons for the lamentable delay in developing the power available in the water courses of these Islands. This development has lagged long years after the satisfactory demonstration of the engineering and economic success of water power schemes in Europe and elsewhere. Our great resources of coal have, doubtless, been an important factor, and water power will still have to compete with this rival—at all events until public opinion has been awakened to the unwisdom and the danger to our industrial status of allowing to run to waste a perennial source of energy, while lavishly expending at an every-increasing rate the fuel capital of our coal fields. But this excuse—the availability of cheap coal—cannot be urged as adequate in the case of Ireland, which for many years has imported large quantities of coal from Britain.

As far back as 80 years ago water power was largely used in Ireland, and disused mills with derelict water wheels—some of considerable size—are thickly scattered over our river valleys. With the development of steam plant and railway development, an inevitable change took place. It became necessary for industries to take advantage of the new transport facilities, and of the superior labour supply available in populous centres. The water power was precarious, subject to occasional droughts and floods, and, naturally, gave place to the assured continuity of steam power, except in the relatively few instances where turbines were installed, and the other conditions were not unfavourable to the use of water power.

The electrical transmission of energy has changed all this, and it is now seen that the utilisation of our natural stores of energy, whether water power or coal or peat, is not altogether a question for the individual, and that the State must take a hand in the regulation and control of these resources.

There has, hitherto, been considerable vagueness as to the approximate amount of water power which might be developed from the rivers of Ireland. The conformation of the country with its extensive and low-lying central plain and coastal mountains, and the absence of any but moderate falls, gave rise to the belief that there was no power worth speaking of. On the other hand, estimates were made which must be regarded as extravagant. Sir Robert Kane, in his "Industrial Resources of Ireland," made an estimate based on rainfall (which he took to be 36 inches per annum) with an allowance for evaporation losses, and an average elevation for the country of 387 feet. Assuming *complete regulation by storage throughout the year,* he estimated that the available power amounted to 1,275,000 water horse power continuous. If we revise this estimate in the light of more recent data as to rainfall and evaporation, we should have to raise his figures to nearly three millions. Such an estimate may be fairly compared to

that of our coal resources which includes thin and inferior coals, which could not be developed under existing economic conditions, for *complete regulation* by storage of all our water courses is impossible of attainment.

The Water Power Resources of Ireland Sub-Committee investigated the power available on four of the larger Irish rivers, and using this as a basis for their calculations, arrived at the conclusion that 500,000 W.H.P. can be continuously and economically developed for the whole country. Using storage, this is equivalent to 1,750,000 W.H.P. for 8 hours per day for 6 days per week. Want of funds prevented the Sub-Committee from making full investigation of other Irish rivers, but they are satisfied from the data obtained in regard to the Shannon, Erne, Bann and Liffey, that the foregoing estimate is reasonable. They realised, nevertheless, the pressing need for the collection of additional data, and recommend that the systematic gauging of the rivers should be at once undertaken. The rainfall records are also inadequate. Nearly all the existing rainfall stations in Ireland are in low-lying districts, and there is great need of records for elevations of 500 feet and over, and also for determinations of evaporation losses. These were made the subject of recommendations. While systematic gauging of rivers is obviously important, I venture to urge the value of accurate rainfall statistics and data as to evaporation losses under meteorological conditions which exist in Ireland. Such data with the careful study of the geological structure of a catchment area, with a view to determining what underground losses there might be from the area, would enable reasonable estimates of run-off to be made. I am indebted to the Geological Survey of Ireland for the excellent maps indicating the geological structure of the river-basins referred to.

The Committee obtained reports on the Shannon, Erne, Bann and Liffey from the undermentioned engineers :—

Shannon—Mr. Theodore Stevens.

Erne—Mr. Theodore Stevens.

Bann (Lower)—Mr. Charles S. Meik.

Liffey—Mr. J. W. Griffith, in collaboration with Prof. H. H. Jeffcott.

The first three of these rivers have, on many occasions, been the subject of enquiry, and numerous commissions and expert reports have dealt with the problems which at the time were paramount, viz., navigation and drainage. These are set out briefly in the report of the Sub-Committee. Any schemes for the development of water power on our rivers must respect these important interests, as well as that of our valuable inland fisheries, and the difficulty of the problem of reconciling them has, doubtless, been one of the causes of the failure to utilise the rivers for power purposes. Previous schemes for the Shannon and the Erne have involved the diversion of the river—or such part of its water as the guardians of these interests would allow the water power engineer to take—into a head race or canal, and to a point selected for a power station. Such canals are expensive to construct, and the diversion of the water from the river course, especially where the length of the canal is considerable, raises many difficulties. The Sub-Committee considered, therefore, a scheme of development which would not involve diverting the river from its bed. Instead of constructing a long and expensive head race, they suggested, instead of the single power station, three or four smaller ones, electrically connected. At first sight such an arrangement would seem to be uneconomical. Investigation shows that this is not the case. Although several barrages are required instead of one, the great cost of a long head race is saved. The necessity for compensation water is avoided, and interference with fishing interests is reduced to a minimum. A marked advantage is that the scheme can be developed in stages as the demand for power develops. It was with these advantages in mind that the Sub-Committee submitted the suggestion to Mr. Theodore Stevens who, after careful consideration and investigation, submitted schemes both for the Shannon and the Erne, based on this principle. These schemes not only secured a far larger output of power, but secured it at a much lower cost per horse power in each case.

The schemes for all four rivers involve storage. In the case of the three larger ones, natural reservoirs exist in the loughs which lie on their courses and the level of which it is proposed to vary. In the case of the Liffey, it is proposed to construct a barrage across the gorge at Poulaphouca, and thus create an artificial lake. The flooding of 4,000 acres will raise the water level in this storage reservoir to the 600 feet contour line, and this will permit of a

complete regulation of the flow. The Sub-Committee attach great importance to the provision of adequate storage. The topographical and meteorological features of Ireland render storage desirable, not only with a view to fully developing water power for industrial purposes, but also of regulating river flow, and thus mitigating on the one hand the effects of drought, and, on the other, preventing the floods which effect such damage along the low-lying banks of many of our rivers. From the point of view of power production, the conservation by storage of the excess winter flow for use during the summer months is analogous to the part played by the summer melting of glaciers in regions where they enjoy the advantages of a *regime mixte*. There seems a tendency to regard storage as a *pis aller*. It is, in fact, of the essence of these schemes.

The limit of time set to a lecture will not permit me to deal with these rivers in detail, but I have compiled from the Report the estimates of power and cost of the schemes which are set out in the following table :—

that the Liffey and the Bann will be the first Irish rivers to be developed.

The mountain lakes of Donegal, Connemara, Kerry and Wicklow offer great possibilities, and it is estimated that an aggregate of at least 40,000 E.H.P. continuous might be developed from them. Some of these lakes could yield 500 E.H.P., the average being about 175 E.H.P. In many cases, at all events, these would be of great value to local industry, for it would seem that the capital cost of development would be low, in some cases as low as £30 per E.H.P.

If we accept the careful estimate of the Irish Sub-Committee that there are half a million water horse power available continuously in Ireland, we may arrive at an approximate idea of its money value. It does not seem likely that the estimate of coal consumption in existing steam plant, which was taken as averaging 5 lbs. per horse power hour, is over the mark. Taking this as a basis, our undeveloped water power is equivalent to 7,500,000 tons of coal,

	Electrical Horse Power		Cost.			
	Installed.	Average continuous.	Total.	Per Horse Power Installed	Per Horse Power continuous.	
			£	£	£	
Shannon	65,900	52,500	2,834,000	43	54	Four stations between Killaloe and Limerick.
Erne	71,300	45,500	2,060,000	29	46	Four stations between Belleek and the sea.
Bann (Upper) ..	(*a*) 13,424	5,369	759,200	56.5	141.3	With load factor of .4
		5,369	360,800	—	67.2	With load factor of 1
	(*b*) 11,932	4,772	748,500	62.75	156.8	With load factor of .4
		4,772	340,800	—	71.4	With load factor of 1
Liffey	29,600	8.300	920,000	31	111	Six stations.

The proposed scheme for the Liffey is of great interest, because of its neighbourhood to the great industrial centre of Dublin. It is estimated that it would be possible to deliver power at low tension in Dublin amounting to 48 million units in a mean year, and would cost about ¾d. per unit. The total output of all the electric power stations in the Dublin district amounts to nearly 31 million units. It seems probable

or, taking the money value of power at, say, 1d. per B.O.T. unit, our half million W.H.P. has a value of about £10,000,000 per annum. Moreover, supply of power for industrial purposes, at the rate of 1d. per unit, would confer enormous advantages on our industries. These facts are not yet fully appreciated. Ireland, it is urged, is an agricultural country, and the suggestion is that it cannot be an industrial country.

A suggestion of water power development, and the provision of cheap power for industries, is met by the exasperating retort that there are no industries to employ the power. The lack of cheap power has been often urged, with good reason, as a reason for our industrial backwardness.

So far as Agriculture is concerned, it is much to be desired that Ireland should become more agricultural—using the word in its truer sense. The decline of tillage in Ireland has been almost continuous since the middle of last century, and while the number of cattle has correspondingly increased the population of the country has declined with hideous regularity until it is now about half what it was in 1841. Increased cultivation and resuscitated industries would repair this. Increased cultivation will be secured by diminishing the cost of production and the supply of cheap electrical power for farming operations will aid in bringing this about. Similarly, the supply of cheap power to the country towns will not only enable existing industries to compete on fairer terms with their rivals, but will, beyond question, lead to the establishment of new industries. I need scarcely say that this argument is not exclusively applicable to Ireland, but, for reasons which I cannot here discuss, the application of our natural power resources to industrial development has been shamefully tardy, and there is danger that if further delayed we may lose much of its economic value. This tendency in such matters to wait for an almost mathematical demonstration of success before adventuring is a national failing. On this point I hope you will allow me to make a brief digression. Twenty-one years ago I was visiting the works of Messrs. Escher Wyss, at Zurich. They informed me that they had just been supplying plant for a hydro-electric station near Grenoble. This station was the first to be installed in this district and was for a new company, *The Société hydro-électrique de Fure et Morge*, and there were points of interest about it that seized my attention. Grenoble, a town of some 80,000 inhabitants, is the principal town of the Department of the Isère. Its principal industry is glove-making. The Department of the Isère is agricultural, but has now become an important industrial region. It has considerable deposits of coal, lignite and iron. Some 12½ miles down the Isère, north-west from Grenoble, along the valleys of the Fure and the Morge, are scattered a number of industries—paper-making, silk-weaving, tool and saw mills. About 21 years ago the manufacturers in these valleys sought to employ electric energy as a motive power. They agreed to co-operate. *The Société hydro-électrique de Fure et Morge* was formed in order to organise the supply. The manufacturers referred to became members of the syndicate and undertook before the station was erected to use 3,000 horse-power. It was a condition that, at the expiration of thirty years, the syndicate should become the proprietors of the whole installation and the capital of the Société hydro-électrique, should be amortised and the Company itself cease to be. A suitable power site was found at Champ on the Drac, about 16 kilometres south of Grenoble. The scheme was carried to a successful issue and exhibited many points of interest as a pioneering effort. I should not be justified in describing the station, but it is interesting to note that the voltage employed (26,000) was the highest used in France at that date. Also, that reinforced concrete was used for the pipe line over a section 2,100 metres in length. This, I have said, was a pioneering effort, and it was quickly followed by others. The Grenobloises did not wait for an industry to be established before supplying cheap power—they supplied the power and this begot the industry. I visited Grenoble last year and found it a hive of industry. There were by March 1st, 1916, in the Department of the Isère, no fewer than 21 companies with 31 power installations, having a total output of 170,330 horse power in addition to a large number of installations of less than 800 h.p. About half the power generated is used locally for electro-metallurgical and electro-chemical industries. On this date, seven other generating stations—for a normal output of over 47,000 h.p.—were under construction and during the darkest days of the war schemes for commercial and industrial construction formed the subject of lectures and propaganda in which the Grenoble Chamber of Commerce played a leading part.

The bearing of this brief recital on our own problems does not need comment.

In conclusion, I should like to emphasise the importance of establishing an Authority to take control of our water resources.

The principal function of such an Authority would be to allocate water as between the different interests—power, navigation, fisheries, potable supplies, etc. There should also be established a National Service having for its object the development of our water power resources. There are strong arguments in favour of such a service taking over control of sources of power supply. Mr. Laurence Kettle, the City Electrical Engineer of Dublin—who was a member of the Irish Sub-Committee on Water Power—has in an article on "Ireland's Sources of Power Supply" in the current number of "Studies," boldly advocated the State taking possession of the sources of power supply, and is of opinion that this will be a cheap and simple matter as there are few vested interests to be bought out. It does not seem to be useful to discuss this large question at the present moment, but it is certain that, in order to secure efficiency and economy in the utilisation of our power supplies, the State must undertake the control, conservation and development of these, and that the question is one which should be tackled at once.

DISCUSSION.

Dr. J. A. Harker, F.R.S., said the author, in his very interesting paper, had referred to the many attempts that had been made by inventors and adventurers of all kinds to deal with the problem of the drying of peat, and had mentioned that those people had been, up against the first law of thermo-dynamics. Personally, he would have expressed that statement a little differently by saying that they were battling against a constant of nature, namely, the high value of the latent heat of steam. The fact that the latent heat of steam, which expressed in centigrade units is 539, was so high, was a most convenient thing for the steam engineer who was thinking of turbines and machinery of that kind, but it was a serious disadvantage for the man who wished to get rid of water from peat. The economics of the question of the utilisation of peat largely lay in the fact that the substance which had to be got rid of out of the peat contained the largest amount of latent heat of any material. If it had been as low as alcohol, it would have been a very simple problem indeed. It had been pointed out by the Canadian Department of Mines, in one of their admirable periodicals, that to dry peat containing about 85 per cent. of moisture required the expenditure of the whole calorific value of the resulting products. Supposing that with a ton of theoretically dry material, whose calorific value was somewhere between 9,000 and 10,000 B.T.U.'s per pound, an endeavour was made to start a peat factory with the object of drying some wet material. If roughly seven tons of the material to which the author referred containing 90 per cent of peat were used, there would then be only enough energy in one ton of dry stuff to get rid of the water, and, therefore, the whole process was somewhat like a serpent swallowing its own tail. There was so little margin that it was impossible to be sure whether the economics of the business were sound or not. That was also on the assumption that an absolutely perfect machine was used which got rid of the steam at a moderately low temperature, the supposition being made that an evaporising process with warm gases was being used, and that the gases were being taken away from the machine at something like 600°F., no account whatever being taken of the inefficiency due to radiation losses.

Some time ago it was part of his duty to visit the works of the Wet Carbonising Company, which was one of the largest undertakings, formed with the object of drying peat on a big scale He remembered on that occasion being told that if the scheme worked in the most successful manner, it was only hoped to get between 5 and 10 per cent. of the whole output of briquettes left over as the ultimate result after the peat had been treated. The company claimed that the process, which was a briquetting and nitrogen recovery process, would give blocks probably harder and of a higher calorific value than the macerated peat shown that evening, although these briquettes did not differ greatly in appearance and properties from the briquettes obtained from powdered coal in South Wales. The briquettes, however, only consisted of something like 5 per cent. to 10 per cent. of the whole material treated. Roughly, 90 per cent. of what was made was consumed in the process, in order to supply fuel for one or other of the requirements—fuel-gas or power to drive the crushing machines, the squeezing presses, and various other machines used in the process. The author had referred several times to Irish dried peat as containing 25 per cent. of moisture. The speaker would be very glad to hear that he was wrong, and to learn that the author possessed evidence that 25 per cent. was the average figure. He thought he was right in saying that in Italy, where the atmospheric conditions were probably a great deal more favourable for air-drying than in Ireland, the statistics showed that from 30 per cent. to 33 per cent. was the figure obtained with moderate air-drying. If 25 per cent. was obtained in Ireland, he thought the author was to be congratulated, particularly in view of the fact that the atmosphere was undoubtedly a great deal damper in Ireland than in Italy.

In the report of the Nitrogen Products Committee, published two years ago, reference was made to an important Irish peat scheme in the North of Ireland, in which the promoters proposed to gasify part of the peat. They produced electricity with part of it; recovered the nitrogen as ammonium sulphate, and the material on which they were supposed to be working was said to contain an average of about 2 per cent. of nitrogen. It was proposed, in the first place, to air-dry the peat and then further to reduce the original water content, which was of course, high, varying from 85 per cent. to 92 per cent, by means of hot gases. By that method it was proposed to dry a portion of the material until it contained a water content of only 15 per cent., and then use it as peat fuel to generate electricity on a considerable scale By far the most important source of revenue from the original scheme was to be obtained from the sale of the sulphate of ammonia. Of the many products derived from peat, sulphate of ammonia was incomparably the most important as a commercial asset It was far more important than the tar oils and the other by-products. The available nitrogen contents of the particular class of peat that was to be worked was of first importance, because if a good deal of sulphate of ammonia could be obtained from it that would prove to be a very valuable asset. If the peat contained little nitrogen, say, only 1 per cent., it was nearly as costly to put up the plant to recover that 1 per cent. as it was to recover a reasonable proportion from the 2 per cent. or 3 per cent. material existing in Norfolk. He thought it was well worth drawing the attention of those who were trying to develop Irish peat bogs to the fact that sulphate of ammonia obtainable from peat was one of the chief economic factors in the whole situation.

PROFESSOR H. H. JEFFCOTT thought that the subject of the paper had been well-chosen in that both beat and water power were contained in it, as he was of opinion that these two questions had a bearing one upon the other. After all, power was the real unit and a fundamental condition of the age in which we lived. Present day civilisation depended on power to a greater extent than many people realised. He therefore thought that Mr. Fletcher had done well in the selection of the title of his paper and in giving an account chiefly of these two sources of energy. A good deal had lately been heard about the depression that existed in industrial life, but he hoped they would have sufficient enterprise and courage to go ahead in spite of difficulties and make successful development of the natural resources that had been proved to be available. He was sorry he was unable to say very much from the point of view of peat, but he had been associated with the problem of water power in Ireland and he knew that this resource was of very great value. There was economically available in the water resources of Ireland about seven times the amount of power that was at present being consumed for industrial purposes, and it could be obtained much more cheaply than power developed from coal in the locality. The cost of water power might be from one-fifth to one-tenth of that of power from coal in Ireland. Very great results were to be expected from water power in that country if the subject was handled in a sound way. The author had outlined in his paper, the systems that had been proposed for dealing with four of the principal Irish rivers He hoped that when the works referred to were completed they would be examples for a long time of the comprehensive method by which rivers of the kind should be dealt with. It was of great importance that the whole river should be developed in such a way as to secure the greatest possible economic benefit, not only in water power but also having regard to navigation, fishery, drainage, and other interests in the river. He hoped that such comprehensive treatment would always be insisted upon

DR. J. F. CROWLEY said the Canadian Government were the first Government to appoint a Power Commission, dealing with problems of the character referred to in the paper, as distinct from Commissions dealing with electricity obtained from water, peat, coal or other possible sources of power Turning to the headings under which the author had dealt with the subject, the first being coal, the author had pointed out that for domestic purposes in Ireland some 3,000,000 tons of coal per annum were used, while on the other hand for industrial purposes only 1½ million tons of coal were employed. While he was acting as Irish representative on the Electricity Supply Committee of the Board of Trade, he obtained some statistics with regard to the consumption of coal for various purposes in Ireland, and found that approximately 4½ million tons were used by the railways. That meant that an extraordinarily small quantity of coal was used for power purposes in the whole of Ireland, in fact on investigation it was found that approximately 300,000 horse power was the sum total of the horse power used for industry in that country as compared with over 13,000,000 horse power in England. That showed what an appallingly backward position industrial Ireland occupied. The author had pointed out that the equivalent of 3½ million tons of coal was raised annually in peat from Ireland. He was very glad that Dr. Harker had spoken so definitely on the subject of peat, because he very much feared that with the development of industry in Ireland, undue attention might be paid to developments that would not pay and which were unsound economically. The author had drawn attention to the fact that it was necessary to handle 200 tons of peat in order to obtain 25 tons of peat that could be dealt with, and that 1¾ tons of

the latter article was equivalent to one ton of coal. The economic position in regard to peat was extremely difficult, and he advised those bodies in Ireland which would have the development of the power resources of the country under their control to move very slowly and very cautiously with regard to any expenditure on peat from the point of view of power production Personally he was very definitely of the opinion that peat should follow after water in the development of the resources of the country. Some water resources had been thoroughly investigated. and from the point of view of present day power economics they were a first class proposition to develop in many cases, particularly where the power existed and the demand for it The author had shown some figures illustrating that the cost per horse power was extremely low. It was only fair to point out, however, that those particular schemes would have to wait for some little while because they were very remote, even from an electrical transmission point of view, from centres of industry The river Bann, however, was within 30 miles of Belfast and also within 15 miles of three other centres of industry, while the Liffey Power Station was within a somewhat similar distance of the city of Dublin Therefore, he thought the cost per horse power of developing the Bann and the Liffey did not compare favourably with the cost on the Erne and the Shannon With regard to peat, the author pointed out that, taking 12/- a week as the cost of labour for a week of 72 hours, the cost of a ton of air-dried peat was 6/-, that ton of peat comparing in the ratio of 1¾ to 1 with a ton of coal. Generally speaking the power situation in Ireland might be summarised as follows:—that from the point of view of power development on anything like a large scale there were perhaps four or five water power schemes that would bear development immediately the power needs justified them, and in two cases the power needs justified them at the present moment Once those water schemes were developed, coal stations were the only practicable undertakings on a large scale. Coal, apart from water, was the only possible source of cheap power. There was no doubt, however, that the Irish Government should carefully watch the developments that took place in connection with peat in Sweden, Denmark and Canada and carry out experiments on the subject. Speaking not from the point of view of an enthusiast of peat but from the point of view of a power engineer, in his opinion power would be developed firstly from water and secondly from coal. Turning for a moment to what was practical politics, the question arose as to what steps should be taken to develop power possibilities immediately. The author had suggested that the water companies should be taken over by the State, and that a body should be appointed to deal with water and its allocation. When the Irish Water Resources Committee sat and considered what report it should make to the Board of Trade, it must be borne in mind that at the time the country was under the shadow of changing political conditions It was necessary to remember that, because it was possible that the Report would otherwise have taken into consideration the proper Irish Ministry to deal with the subject. When they were acting under the shadow of changing political conditions their ideas as to the administration and executive functions of the bodies proposed were certainly governed to a certain extent by those conditions. He ventured to suggest that rather than appoint either a Water Commission or a Peat Commission or even an Electricity Commission on the lines adopted in this country it would be wise for those dealing with those matters in Ireland to consider whether an over-reaching power Commission, with power to deal with every possible source of power with a view to conserving the natural resources of the country, would not be a better body to appoint. He spoke loyally as a member of the Committee which made the Report, which was quite soundly made on the views that could be taken at that particular period, but conditions had changed. Viewing things in a broad way, he thought a Power Commission of the nature he had suggested would be a better body to appoint than either a Water Commission, an Electricity Commission, or a Peat Commission Any body which was appointed should have administrative and executive functions with powers of initiation, because if there was one thing more than another in which Irish conditions differed from the more established conditions in this country it was that the initiative had been expected to come, in the conditions that had existed in the last hundred years, from outside rather than inside. For some time to come that expectation would continue, and it was desirable the Government should realise that that expectation existed and provide the initiative itself.

MR. THEODORE STEVENS, in dealing with a point referred to by the previous speaker, said that personally he would desire a Commission to be appointed to deal not only with power but industry. One thing for which he wished to apologise in his report on the water power of Ireland was that he worked out the cost assuming a 42 per cent. load actor, but it was necessary first of all to establish industries to utilise the power before such a load-factor could be obtained. Between 20,000 and 30,000 tons of carbide were imported into this country per annum, and a great amount of cyanamide, and he saw no reason why Ireland should not make all the carbide and cyanamide that were used in the British Islands. There was sufficient power for the purpose in Ireland, and that would have the effect of developing the load factor obtained from the use of water power. He quite agreed

that the Liffey was the first river that should be developed if Dublin was being depended upon for power, and that the Bann should be developed next if dependence was to be placed on that district for power, but he suggested that the industries should be placed alongside the River Erne and the power used in that district. At least 10,000 horse power could be utilised for the manufacture of carbide, which would profitably employ hundreds of men and would be of the greatest possible benefit to Ireland.

MR. FLETCHER, in thanking the speakers for the reception accorded to his paper, said that he fully realised its defects, which were largely inherent in a short paper dealing with a big subject. Dr. Harker doubted whether it was possible under the meteorological conditions in Ireland to secure peat containing only 25 per cent. of moisture, which he pointed out was drier than the peat obtained in Italy. He was afraid Dr. Harker was not acquainted with the fickleness of an Irish climate. It was impossible to say what degree of dryness might be produced in a single season in Ireland. Sometimes peat was obtained that was much drier than 25 per cent. and sometimes less. Of course, he would not like to trust to a rough estimate made by a peasant, who only knew what he called "good" and "bad" peat, and if asked whether it contained 25 per cent. or 30 per cent. of water no very clear information would be obtained from him on the subject. In some seasons, however, peat drier than 25 per cent. was obtained. It was necessary to take some standard for what was commonly and loosely spoken of as "air-dried peat," and 25 per cent was a convenient figure for the purpose. He was quite aware of the vast importance of the nitrogen content, but as his paper did not deal with the by-products of peat he carefully refrained from saying anything about that vitally interesting question. He might say, however, that the nitrogen content of Irish peat compared very favourably with that of almost any other peat, some of the Irish bogs having quite a high nitrogen content. It had been suggested again and again that in those cases where peat was used in producer plant the by-products should be utilised. At present the by-products in the case of the Portadown installation were thrown away and an output of a certain magnitude was required before it was possible to deal with them economically; but he had no doubt that the economics of a large and well-considered scheme would be considerably affected by the return obtained from the by-products. Dr. Crowley had suggested that, after water power, coal was the next source of power that should be developed. Personally, he did not know on what grounds Dr. Crowley rejected peat, because he was quite satisfied that there was great hope for its economic utilisation, and he thought there was a much greater hope since the Water Power Report had been issued, because one scheme would considerably help the other. The Peat Committee Report advocated air drying with a minimum of handling, and he thought it was quite likely that large peat stations would be erected. As Dr. Crowley pointed out, a large quantity of water had to be dealt with, but that had been taken into consideration in the scheme that had been suggested. The water would be got rid of by air drying.

DR. CROWLEY said the only point he had made related to the order in which the schemes should be carried out. Personally he thought that coal should be dealt with before peat

MR. FLETCHER said he was not prepared to accept that suggestion. It was necessary to consider the geography of the coalfields. The Leinster coalfield was the most promising, and that contained anthracite coal which was used almost entirely locally. Until the line was built, by means of which Castlecomer was joined up with the local line, the bulk of the output from Castlecomer was distributed in carts and motor lorries to Kilkenny and the surrounding towns. At the present time if anyone in Dublin desired to get a load of anthracite for domestic use it was difficult to obtain it He had often wondered why more of the Kilkenny anthracite was not distributed. It was entirely a matter of competition with other coals and other fuels, and in that connection it must be borne in mind that the cost of winning Irish coal was very considerable. In reply to Mr. Theodore Stevens, who had referred to the large amount of calcium cyanamide imported into this country, he was happy to say that there were two calcium carbide factories in Ireland. The further stage of conversion into cyanamide was an important process, and, as had been stated, that was one of the industries which might be developed in Ireland. The three essentials for the manufacture of calcium cyanamide were power, a suitable carbon and limestone Underlying nearly all the Irish bogs there was a good limestone ; anthracite was mined in the country, and a source of power existed in the bog itself, so that he thought there was a very promising field waiting to be developed

THE CHAIRMAN, in moving a very hearty vote of thanks to the author for his excellent paper, said that, in spite of the great disadvantage from which he had suffered in its preparation and delivery, he had read an admirable, well-balanced paper on three very difficult subjects.

The resolution of thanks was carried unanimously and the meeting terminated.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2

NOTICES.

CHAIRMANSHIP OF COUNCIL.

On Monday, July 10th, at their first meeting in the new Session, the Council elected Lord Askwith, K.C.B., K.C., D.C.L., Chairman for the ensuing year.

CLOSING OF THE LIBRARY.

Owing to the work of renovating and decorating the Society's house, the Library and Reading Room will be closed until further notice.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

SIR GEORGE BIRDWOOD MEMORIAL LECTURE.

Friday, May 26th, 1922.

The Right Hon. Viscount Peel, G.B.E., Secretary of State for India, in the chair.

The Chairman, in introducing the lecturer, said that Sir Thomas Arnold was well-known as the greatest authority on the Muhammadan religion that this country possessed.

The lecture delivered was

INDIAN PAINTING AND MUHAMMADAN CULTURE.

By Sir T. W. Arnold, C.I.E., D.Litt., M.A.,
Professor of Arabic, School of Oriental Studies.

Those of us who had the privilege of hearing the two former Sir George Birdwood Memorial Lectures have been led to associate with this foundation orations upon some of the weightiest problems connected with the Indian Empire, set out with all the dignity of finished oratory and replete with the wisdom and knowledge of publicists of ripe experience. A mere pedant might well hesitate to follow where Sir Valentine Chirol and Sir Edward Grigg have given such a distinguished lead, but I take encouragement from the thought that the subject I have chosen is one that would have been of interest to Sir George Birdwood himself. He was one of the first to draw attention in this country to the minor arts of India, and Indian paintings had hardly been studied at all when he pronounced the judgment that they were equal in merit to the paintings of the same age in Europe. Indian art was of interest to him as an expression of personality, and his enthusiastic love for the Indian people caused him to take delight in any manifestation of their artistic activity that brought him into touch with their daily life or in any way aided insight into their ideals. No aspect of their thought or behaviour was without interest for him, as those who enjoyed the privilege of his personal friendship will well remember, and, thus, though you may be disappointed in a lecture that falls so far below the lofty aim of those to which you have listened on previous occasions, I have selected my subject as being one which I know would have gained the approval of the great man in whose memory this annual lecture was instituted.

The modern student of history is accustomed to an ever-widening definition of the subject of his study. History has long ceased to mean to us merely political history, and the rise and fall of dynasties. The modern historian recognises the interaction of innumerable factors—religious, economic, social; disease has been brought in to explain the decay of the influence of ancient Greece, and the austerity of the Catholic Counter-Reformation; art and literature are recognised as important factors in the development of a people. Consequently, the historian nowadays throws his net wide to gather in

material for his account of any period, and no longer confines himself to the written record of the chronicler. One of the results of this wider outlook has been the use of illustration even in serious works of historical research. In this respect French and German scholars have shown the way, for such aids to the understanding of history have found little favour in this country except in school books and popular histories. But those who despise illustrations in books of history may well be reminded that for the primitive periods of the life of humanity, pictures are our only historical documents, and that without the cave drawings we should know little indeed of the life of the earliest inhabitants of Europe. The invention of writing for a long time caused the importance of all other kinds of historical documents to become obscured; but now even the most eminent British historians are beginning to follow the lead of their Continental colleagues in the use of pictorial illustration.

The purpose of my lecture, then, is to suggest some of the directions in which research into the history of Muhammadan India may be pursued, so as to throw fresh light upon aspects of Muhammadan life and thought that the historians have hitherto neglected. Now the study of India is our peculiar domain; no country in Europe possesses so rich a store of material for the purpose in records and manuscript documents of all kinds; written and printed sources are indeed receiving attention, but hitherto little use has been made of pictures as aids to historical research. The fact that so many of our writers on Indian history attempt to survey the whole field from Vedic times to the present day precludes the possibility of any illustration beyond a few historical buildings and portraits. What we now need in Indian history is an increasing number of monographs, and studies of separate aspects and periods in much greater detail. Possibly, also, a fresh point of view may prove to be enlightening, and may establish the falsity of Sir Henry Elliot's complaint against the Muhammadan historians of India that their annals comprised "for the most part nothing but the mere dry narration of events . . . . without any observations calculated to interrupt the monotony of successive conspiracies, revolts, intrigues, murders and fratricides." He goes on to say: "Of domestic history we have in our Indian Annalists absolutely nothing; . . . . . . by them society is never contemplated, either in its conventional usages or recognised privileges; its constituent elements or mutual relations; in its established classes or popular institutions; in its private recesses or habitual intercourses."

Even to the student of historical documents, which Sir Henry Elliot collected with such persevering assiduity, this complaint seems strange, because the chronicles and other records, which he made known to us in his monumental collection, the "History of India as told by its own Historians," contain an immense amount of material which, if thoroughly studied, would go far to remove the grounds of his complaint. But these documents are waiting for a more careful examination than they have yet received, and when they have been re-read they will reveal the operation of factors that have been, in some instances, more potent than political activities. For this more careful scrutiny of documents, such pictures as are available may provide valuable suggestions, and I propose to make use of them in order that we may see what they have to tell us of the "private recesses or habitual intercourses" of Muhammadan society.

I shall confine myself here to the later period of the Muhammadan history of India, in the 17th and 18th centuries. For this period the number of pictures available is not large, but they are sufficiently numerous to afford useful indications of aspects of social life to which the historian has hitherto devoted little attention. Nothing like a complete survey of the subject can, of course, be attempted here, as the extent of it is much too vast for the narrow limits of a single lecture, but a few distinctive features may be chosen to serve as indications of the directions in which further study and research may achieve valuable results.

One important aspect of the history of Muhammadan rule in India that has not yet received adequate treatment is the religious life of Islam in its various phases and developments. The local peculiarities of Islam in the different parts of the world in which it has found a footing have attracted the attention of students of religion for several decades, but we still lack any comprehensive work of this kind

dealing exclusively with India. The subject is a vast one, and, of course, many of its peculiar phases find no expression whatsoever in art. But Indian paintings emphasise one aspect of the religious life of Islam in India, which is of prime importance—the reverence for saints and ascetics, the submission by the faithful of their spiritual life to the direction of religious guides and teachers. One outcome of this blind submission to religious authority was the enormous expansion of the Islamic religious orders in India, and portraits of the more famous saints belonging to the various orders are common. The imperial house was not behind any of its Muslim subjects in the reverence that its members paid to saints and ascetics, and we have many pictures that show us some emperor or prince of the royal family visiting a holy man. The equality of all believers in the bonds of faith, which is one of the fundamental tenets of Islam, finds striking exemplification in the reverence paid to the religious teacher—and sometimes, indeed, demanded by him. There is a story told of the Emperor Aurangzeb that on one of his progresses through his kingdom he came to the place where an ascetic lived, and expressed a desire to see him; the holy man refused to leave his house, and sent back a message that if the Emperor wished to see him, he must come himself; and this Aurangzeb did, behaving himself with all humility, in the spirit of true Muslim piety.

These Muslim ascetics, in their desire for retirement, often avoided the haunts of men, and, like the Hindu sannyasis, retired into the jungle. Of one such saint—Miyan Hatim, of Sambhal—it is told that for ten years he wandered about in desolate country, bareheaded and barefooted, never once, during all this time, sleeping on a bed. Another saint, Shaykh Muhammad Ghawth, whose tomb is one of the finest monuments in Gwalior, lived a life of austere ascetism for twelve years in the low hills of Chanar, north of the Ganges, dwelling in caves and living on the leaves of trees. Even after they had settled down, such ascetics would shut themselves up for long periods of meditation, and dwell in a lonely cell or a wood. In the later periods of Muhammadan rule, the tomb of some famous saint would serve as the gathering place of his followers in the same spiritual succession, and great establishments of this kind are scattered all over India. But it is the solitary ascetic that the Indian painter generally preferred to depict.

Another characteristic feature of the life of these holy men was the state of religious ecstasy, which was induced in various ways, but particularly by religious dancing, or by innumerable repetitions of the name of God, or of some religious formula. The biographies of Indian saints tell us many stories of such ecstatic trances under varying circumstances, but the painters, by predilection, represent those which took place during the mystic dance. This form of expressing religious emotion has met with stern disapprobation from most of the orthodox theologians of Islam. The mystics have sometimes allowed it, sometimes looked upon it askance. But in India, despite all hostile criticism, dancing and other external manifestations of ecstatic emotion acquired a considerable vogue in religious circles, especially among the members of some of the religious orders.

These mystics defended such violent expressions of emotion by stories told of the Companions of the Prophet, one of whom hearing a man recite the words of the Qur'an, "Verily the punishment of thy Lord surely descends; there is none to hold it back," (52, v. 8) uttered a loud cry and fell down in a faint; he had to be carried into his house, and lay sick there for a whole month. Many such stories were told of the later saints also—how, under the stress of religious emotion, when the heart was thrilled with rapture and their ecstasy overpowered them, they would shriek and faint, or even die straightway. Such stories found special favour in India, and many of the Indian saints became famous for their ecstatic moods and especially for their habitual observance of the practice of dancing. Of Shaykh Aziz Ullah (ob. 1567) it is said that in his ardent longing after God he wept so continually that the world has never seen the like: as soon as the sound of a holy song or chant fell upon his ear, the effect was like that of a tempestuous wind; every morning and evening he would work himself up into a state of ecstasy, and his example was so infectious that it was said of him that could a flint have looked upon him on such an occasion, it would have become softer than wax. If such miraculous influence were lacking, other mystics, such as Shaykh Fakhr ud-Din (his contemporary), would accept no excuses from the spectators, and would insist upon

all present joining him in the dance.

So far we have considered only some of the religious observances of the Muslims themselves, but the painters draw our attention to the relations that were established between the dominant faith of Islam and the beliefs of the Hindus. The hostility of Islam to the idolatrous system of Hinduism is one of the most obvious features of the relations between the Muhammadan invaders and the earlier inhabitants of India. But the brutal massacres of Brahmans, and the looting and destruction of temples that marked the raids of Mahmud of Ghazni, could not possibly remain as a permanent feature of the conquest, after the invaders had once settled down in the country. Some *modus vivendi* had to be established, and the historian of India has yet to enlighten us as to the extent of the toleration that Islam extended to Hinduism, —upon what theoretical foundation it was based, and how it operated in practice. We want to know not only what was the practice of the State and of the officials of Government, but also the personal relation of individual members of the rival faiths. In this connexion one of the most interesting figures in the Muhammadan history of India is Dara Shikoh, whose disastrous failure to defeat his brother in the struggle for the throne is one of the tragedies of Muhammadan history. He appears to have been animated with somewhat of the spirit of his great-grandfather, Akbar, in attempting to bring about some form of reconciliation between Hinduism and Islam. It is strange that no historian has yet attempted to write a separate biography of Dara Shikoh; for he possesses something of the same pathetic attractiveness as Frederick II. Hohenstaufen; both were princes of enlightened and tolerant religious views; both of them devoted sympathetic study to the doctrines of a creed that was not their own. They paid the penalty of a liberality of spirit in advance of their age, and were wrecked on the rocks of a pitiless fanaticism. Had Dara Shikoh met with success in his efforts to draw the adherents of the rival creeds of Islam and Hinduism together, by emphasising the doctrines and the philosophic conceptions that both Hindus and Muhammadans could hold in common, the history of India might have been very different. He cultivated the society alike of Muslim saints and Hindu sannyasis, and, approaching his own faith from the stand-point of Sufiism, he came to the conclusion (as he states in one of his writings) that the divergence between the doctrines of the Hindu pantheists and those of the Muhammadan mystics was verbal only; and he wrote a book, entitled "The Confluence of the two Seas," with the object of reconciling the two systems.

Among the Hindu Yogis, whose society he frequented, the name of one, Baba Lal, has been recorded. This ascetic settled near Sirhind, in the Panjab, where he built himself a hermitage by the side of a temple. He gathered round himself a large number of disciples, and among those who were attracted by his teaching was the young prince, Dara Shikoh. Two learned Hindus, who were in his service, put down in writing a record of the conversations that took place between him and Baba Lal on several different occasions in the year 1649 when Dara Shikoh, who was then aged 34, visited him, and these dialogues are still extant in manuscript, but have never been printed. Such friendly intercourse between members of the rival creeds, sundered from one another at times by rivers of blood, stands out as one of the most attractive chapters in the religious history of India. Art comes in here to establish the existence of what some historians have believed to be impossible. It is strange indeed how little attention it has received, and it still remains for some student of religion to collect together such instances as may be found in the Acta Sanctorum of Hinduism and Islam. One example may be given here from the legend of two ascetics in the Panjab, Dial Bhavan, a Hindu saint, and Jamali Sultan, a Muhammadan. Their tombs still stand close together at Girot, as a symbol of the friendship that united them in life. Of their first meeting a story is told—which appears, indeed, in various forms in other hagiologies — how Dial Bhavan was already settled with his disciples in Girot at the time when Jamali Sultan arrived there. Dial Bhavan sent to the newcomer a vessel of milk filled to the brim, as a delicate hint that the town was already full enough of ascetics, and that he would be well advised to settle elsewhere. Jamali Sultan understood the message perfectly well, but won for himself a welcome by sending back the brimming vessel,

* The lives of these saints have been made accessible to the English reader by Sir T. Wolseley Haig's translation of Al-Badaoni's Muntakhabu 't-Tawarikh, Vol. III. (Calcutta, 1899.)

with a rose-petal floating on the surface of the milk.

We must now pass on to other characteristics of the life of the Indian Muhammadans to which their painters direct our attention. Their art was in the main a courtly art. They painted for the emperor and for the nobles, upon whose patronage they depended for their livelihood. The artist, during the period we are considering, was generally attached either to the royal atelier, which must have been a very large establishment, or was in the service of some wealthy lord. The subjects, therefore, that these painters selected were generally such as had reference to the life of the court, or were of interest to their princely and other patrons.

Of one important section of their work, the paintings of darbars, I do not propose to treat here. Many of these darbar pictures have already been published, and the subject of the darbar, its arrangement, its importance in the organisation of a despotic government, such as was that of the Mughals, have been already studied, —though still inadequately. But of the life of the nobles, apart from their daily attendance at the imperial darbar, and their respective official duties, civil and military, no detailed study has yet been attempted.

On the present occasion it is only possible to make selection of a few of the features of this court life. As is well known, it was one that was governed by strict rules of etiquette. No one has yet attempted to show how the rough, careless Muhammadan invaders of India, after they had firmly established themselves in that country, introduced such polished manners into their court, and elaborated the rules of social intercourse almost into a fine art. The grace and charm of cultivated Muhammadan society form a part of the inheritance of the past, which the Indian Muhammadans of the present generation tend to despise as old-fashioned. But those who have been privileged to know any Muhammadan gentlemen of the old school will remember how their courteous behaviour, combined with personal dignity and self-respect, added charm and attractiveness to social relations with them.

Much of this etiquette, and the culture that went along with it, derived its origin from Persia, for (as is well known) since the time when the Mongol invasions brought ruin and devastation to Central and Western Asia, and destroyed so many centres of Muhammadan culture, refugees fled, in large numbers, into India, for there Muhammadan kingdoms were still stable and safe from the flood of destruction that had overwhelmed so many other Muhammadan states. Among these refugees, Persians formed a large proportion, and Persian poets, men of letters, religious teachers and others exerted a permanent influence on the culture of Muhammadan India. The official language was Persian; in Persian was written the major part of the prose literature and practically all the poetry. Under such a centralised government as that of the Mughals, learned Persians, lawyers, physicians, artists and others, who depended for their livelihood on the patronage of the court, naturally flocked to the capital, and succeeded in winning for themselves an ascendancy in all positions that called for intellectual attainments. The Hindus, it is true, were capable of being their intellectual rivals, but the Afghans, who constituted the other great group of Muhammadan immigrants, were too rough and illiterate to gain much distinction in civil life, and the Persians accordingly came to the front not only in the learned professions, but also filled some of the highest offices in the state. A typical example of such a Persian is Ala ul-Mulk Tuni, who rose to high office under Shah Jahan; he first showed his ability in the ministry of finance; then he was raised to the important post of superintendent of the examination of petitions, and was lastly made Lord High Steward,—an office that placed in his hands the control of the whole expenditure of the royal household. When Shah Jahan was dethroned by his son, Aurangzeb, the new emperor, aware of the fidelity of his father's minister, took him into his own service. Aurangzeb reposed so much confidence in him that he placed him in charge of the deposed sovereign and of the enormous establishment that he was allowed to keep up as a symbol of his former grandeur. Before his death, Ala ul-Mulk had been raised to the highest office in the state, as chief minister. In spite of having had so varied an official career, he found time for the cultivation of intellectual interests and was proficient in mathematics, astronomy and natural science.

Ala ul-Mulk Tuni may be taken as a typical example of the refining influence of Persian culture—the cultivated gentleman, with polished manners, intellectual

interests, bringing the ripe fruit of a trained intelligence and of a mature experience to bear upon the affairs of the state. Hundreds of such examples might be given to show how profoundly Persian culture interpenetrated every section of Muhammadan society in India.

The other great contribution to Indian Muhammadan culture came from Hinduism, and some measure of its influence may be found in the degree of the approximation of the two systems. The great example of the spirit of conciliation and harmony between these rival systems of life and thought in India—Hinduism and Islam—is, of course, Akbar. The failure of Akbar's great attempt at reconciliation has obscured the recognition of the close approximation between Muhammadan and Hindu society that shows itself clearly during succeeding generations, in manners preeminently, and to a considerable degree also in habits of mind and intellectual interests. It is in literature that the most striking evidence of the Hindu contribution towards this approximation is to be found; the Muhammadan influence expressed itself largely in externals, and here art may come to the assistance of the historian, for innumerable pictures of Hindu rajas and their surroundings reveal how profoundly they had become impressed by the Mughal Court, and how largely Muhammadan influences had come to form part of their daily life and manners. The most obvious and visible sign of such approximation between Hindu and Muhammadan culture was costume, and the court dress of the Mughals was not only adopted by many of the Hindu rajas, but even survived longest in Hindu courts; one of the last persons to wear this dress was the late Raja of Bundi, who appeared in it at the Delhi Durbar of 1897, to the amazement of a generation that had almost entirely forgotten the Mughal Court and its fashions.

It is strange that in the vast literature on the history of costume that of Muhammadan India hardly finds a place, in spite of the abundant materials available in the great series of historical portraits to be found in our libraries and museums. As those portraits are better known than almost any other section of Indian Muhammadan painting, I do not propose to dwell upon them here. But to the examples already given, I would add only one which shows the extent to which the skirt became lengthened in the 18th century. It represents Shuja ud-Daulah, the Nawab of Oudh, and his sons. This singular dress is typical of the effeminacy which prevailed in the Muhammadan courts in India during the period of their decline. It finds characteristic expression in the exclamation of the last Nawab of Bengal, when, in the year 1765, he ceased to be even a titular ruler and became a pensioner of the East India Company: "Thank God, I shall now have as many dancing girls as I like."

To this more frivolous aspect of the court life, let us now turn. The question of the place occupied by the dance in Muhammadan society is of great interest, but it still awaits the attention of the sociologist. It has its religious aspect, in the devotional exercises of the religious orders and the practices of the Sufiistic mystics, and as we have seen, there are several Indian representations of such religious dances. Here I shall make brief reference only to its lighter aspects, as represented in Muhammadan painting. How large a part the dancer filled in the life of the later Muhammadan princes and nobles is shown by the fashion that grew up after the death of Aurangzeb for these great personages to have their portraits taken while engaged in watching a dance. We no longer have the austere picture of the noble of the early period of the great days of Mughal rule, standing alone, dignified and erect, or leaning on his sword. But a new convention is introduced in which the noble is no longer shown in the guise of a warrior or statesman, but we see him enjoying his hour of ease.

There is a long series of portraits of this type in which a singer or a dancing girl, either with attendant musicians or with other dancers, displays her art before the prince or noble. It would appear that towards the close of the Mughal period this became an established convention in the art of portraiture, just as the Italian or Flemish noble of the 15th century had himself painted as kneeling before the Madonna, or the Tudor gentleman held in his hand a pink or some other flower, or the mid-Victorian gentleman stood with one leg elegantly crossed before the other. The Muhammadan convention was more picturesque. Unfortunately, as the majority of Mughal portraits are unnamed, it is often difficult to identify the personage represented; but it was a fashion that found favour with even the highest, and one

such picture represents so exalted a prince as Asaf Jah, the first Nizam of Hyderabad (1724-1748).

Many of these pictures are graceful and pretty; the bright colours employed (of which I shall speak later) give them an extraordinary brilliancy, and these colours are set off by broad spaces of white, such as a smooth marble platform, or a white-washed wall. They are also often worked out in much more elaborate detail of accessories than is the case with the more simple and more dignified Mughal portraits of the earlier period.

Another characteristic feature of the life of the Mughal court, which receives abundant pictorial representation, is drinking. As is well known, drinking may almost be called the family vice of the Imperial family. Babur, the founder of the house, has himself put on record the story of his wild drinking bouts, and his descendants showed a similar disregard of the injunctions of the founder of their faith. Humayun preferred opium; Akbar drank both wine and opium; his son Daniyal died of delirium tremens; his heir, Jahangir, flouted orthodox Muhammadan sentiment so far as to strike coins representing him with a drinking cup in his hand, and in his memoirs gave detailed accounts of his drinking bouts. Aurangzeb tried in vain to check these habits of drunkenness and (with the exception of his namesake, Alamgir II., who reigned 50 years after him), was the only one of the Mughal emperors who did not drink. When the rulers thus set the fashion, it is not surprising that the nobles of their court followed their example, and it became quite common for a grandee to have his portrait taken with a wine cup in his hand. Representations of indulgence in other intoxicants occur less frequently. Though the taking of opium was a fairly common practice, it does not appear to have been selected as a subject for pictorial art. On the other hand, the drinking of Bhang, or Indian hemp, often appears, especially in pictures of sannyasis; but as we are only concerned here with the life and manners of Muhammadan society, no reference need be made to Hindu habits. There is preserved in the British Museum a large picture representing the sale of Bhang in Hyderabad, about the middle of the 18th century. At that period there was a well-known seller of Bhang named Matvali Bhang-saz, who received a gold mohur from every customer to whom she handed a cup with the right hand, and a silver rupee if she handed it with the left. This painting gives a lively picture of various types of persons in the Muhammadan society of Hyderabad at this period. We see here the soldier blustering and quarrelsome; the nobles of the court; even dignified respectable members of society have succumbed to the attraction of the pernicious drug.

The prevalence of habits of drunkenness among the higher circles of Muhammadan society makes one wonder how they managed to preserve their health, but, like the English squires of the 18th century they spent much of their time in the open air. They lived in a period of constant warfare, and so the Mughal emperors and their nobles spent a great part of their lives in camp. When they were free from the operations of war, their great amusement was hunting. For this side of their life, there is abundant documentary evidence, and painting supplements the written record.

Let us pass now from drink to food. No serious student of history can undervalue the importance of food in the social economy of mankind. The satisfaction of this primitive need is one of the foundations on which the fabric of organised human society was built, and no study of even the most highly developed civilisation is complete without reference to this source of its continuance in existence. But apart from these economic considerations, there is the important place that food takes in the daily life of any advanced society. Every student of Muslim political history knows how close may be the connexion between an outburst of fanaticism and the month of Ramazan, and the administrator in India is unlikely to belittle considerations of diet. But art has little or nothing to say in reference to these larger aspects of the question, particularly as the school of painting we are now considering is, above all, a courtly art. But in this narrower sphere of the court, a fortunate chance has preserved for us a manual of cookery, compiled for the use of the Imperial household, and as it has hitherto remained unnoticed, some account of it may be of interest here. The date of the MS. is uncertain; but it cannot be more recent than the reign of Shan Jahan (1628-58), and it may, ndeed, be earlier. The pictures in the manuscript show that the Master of the

Imperial Kitchen was a person of considerable importance; he took himself seriously, assumed airs of superiority and dressed like a gentleman in authority, and from what we know of the numbers of the persons who lived in attendance on the Mughal emperor and were fed at his expense, we may form some idea of the difficulty which would be experienced by any one who had to cater for them. In Akbar's palace there were more than 5,000 women, and even in Aurangzeb's there were as many as 2,000, and to these large figures we must add the male members of the establishment before we can arrive at the total number of all those who had to be provided with meals. Abu'l-Fazl tells us that meals were being carried from the imperial kitchen into Akbar's zenana all day long, from early morning to nightfall. Further, if we take into consideration the precautions that an oriental monarch had to take, in view of the risk he ran of possible attempts to poison him, we may realise the importance of the officer who was placed in charge of the kitchen. Hakim Human, who held the office of Master of the Kitchen in Akbar's reign, was a close personal friend of that emperor, and exercised considerable influence at court, and was sent by him as ambassador to the Shaybanid Khan of Transoxiana. Akbar himself was a very moderate eater, and contented himself with only one meal a day, and used to rise from the table before he had fully satisfied his hunger; the cares of state, and his many intellectual interests might well have left him no time to devote to the business of the kitchen. But his biographer tells us that Akbar himself drew up regulations for the conduct of this department, and interested himself in the working of it. How many assistants were assigned to the kitchen we are not informed, but, in view of the enormous household for which meals had to be provided, the number of cooks employed must have been considerable, and beside the cooks, there were tasters and a number of other servants, and with so large a staff we may well imagine that difficulties of discipline might arise. The kitchen had its own treasury and accountants; a budget was drawn up at the beginning of the year, and accounts were submitted every month. The dishes were served up with considerable ceremony. Spectators and idlers were excluded from the kitchen or the place where the cooking was carried on (for, as we shall see, it often took place in the open air). As soon as the food was taken out, it was tasted by the cook and the assistant to the Master of the Kitchen who happened to be in charge of this particular section; then it was tasted by the Master of the Kitchen himself, and put into the suitable dish. The gold and silver dishes were tied up in red cloth, and the copper and china ones in white cloth. Then the Master of the Kitchen affixed his seal to the cloth wrapper, and wrote out a list of the contents of each dish; the dishes were then carried into the royal apartments in procession, with macebearers walking in front of and behind the cooks. The servants of the palace, who broke the seals and arranged the dishes on the table cloth, had also to taste the food, and the Master of the Kitchen had always to be in attendance while the Emperor took his meal.

I conclude my lecture with one more example of the way in which Indian painting may add to the knowledge which we gain of Muhammadan society from written records. In this instance, the evidence I have to present is rather of a negative character; it has to do less with illustrations of contemporary life than with a frame of mind that turns away from the horrors of the present to a dream world of imagination.

In the reign of Muhammad Shah (1719-1748), during the early decades of the 18th century, there appears to have been a short-lived renaissance of Indian painting.

The painters of this school were living in an age that was rushing to its ruin. The Mughal Empire was breaking up; the raids of the Mahrattas rendered life and property insecure. It was unsafe for women to go to the wells outside the city walls for fear of being carried off by marauders. The weakness of the central government left the taxpayer a victim to any local magnate who could attract to himself a body of mercenaries, and life was full of uncertainty and anxiety. These pictures were painted before the crowning horror of Nadir Shah's invasion in 1739, but this disaster, followed a few years later (1756), by the invasion of Ahmad Shah Durrani, struck the death knell of Mughal culture, and painting perished with other arts that lived on the patronage of the court.

The painter of this period no longer goes to sober history or to contemporary personages

for the subject matter of his pictures ; he adds nothing to our knowledge of the times he lived in, for he turns from the miseries of the troubled period in which he finds no outstanding figures to paint, and takes refuge in the realm of fancy. He illustrates fantastic romances, full of fairies and strange monsters, and the adventures of imaginary lovers moving in an unreal world.

This school of painting represents the last effort of Mughal art. Apart from its special choice of subject matter, it has certain distinctive features of its own—brilliancy and vividness of colouring, set off by large white spaces—and is in pleasing contrast to the somewhat drab, uninteresting colouring of many Indian paintings since Aurangzeb's puritanical attitude towards art had withdrawn the imperial patronage from painters, so that painting suffered a miserable decline for a half a century.

It would be easily possible, did time allow, to add to the aspects of history in regard to which Indian paintings may increase our knowledge of Indian Muhammadan society in its various phases, or may suggest new lines of research that have hitherto been neglected ; for there is a rich store of such material lying unregarded in the great collections of this country ; they have received some attention from students of art, but have as yet been little studied as historical documents.

[The lecture was illustrated by a number of pictures, taken from albums and manuscripts in the British Museum, the Bodleian Library, Oxford, and the Library of the India Office ; the greater part came from the last-named Library, which possesses in the collection made by Mr. Richard Johnson about the end of the 18th century, abundant examples of the later schools of Indian painting.]

DISCUSSION.

The Chairman (Viscount Peel) said it was with very great pleasure that he moved a hearty vote of thanks to Sir Thomas Arnold for the very learned, illustrative, entertaining and instructive lecture which he had given. The lecturer had reminded them that historians had discarded their ancient formalism, and were ready to search for materials in many quarters which before would have been regarded as unworthy of the dignity of history. The muse of history to-day was no pedant ; she shortened and lengthened her skirts according to the fashion. It was realised nowadays that for the purpose of interpreting and illustrating contemporary habits, a washerwoman's bill might be of far greater service than the report of a debate in Parliament, and the gossip of the drawing room or the Bazaar of more use than a learned treatise on Hegel. It was obvious from the lecture that many interesting parallels could be found between the habits of the East and the West. The lecturer spoke of ecstasies of religious emotion, sometimes condemned and sometimes applauded by the religious men of the day. That might be compared with many exhibitions and varieties of religious experience seen in the West, and perhaps more particularly in the United States. The lecturer had spoken of the Emperor Aurangzeb humbling himself by going to the house of an ascetic : but there was a famous Emperor of the West who knelt for days and nights in the snow before the castle of a Pope. Personally, he had been greatly interested in what the lecturer had said with regard to religious toleration, the efforts made to reconcile the differences between the observances of the Hindu and Muhammadan religions, and the attempt made by Dara Shikoh to lessen the acerbity which prevailed between them. At the present time, in a neighbouring island, it was being shown what religious intolerance was capable of. A parallel could be found for the elaborate etiquette of the Mughal Courts in the elaborate formalism introduced by Louis XIV. He had formed the impression that the lecturer preferred realism in Art, because he spoke with some irony of what he described as "imaginary lovers wandering in unreal woods." Personally, he thought a touch of imagination might be acceptable after the realistic scenes of dinners and festivities which had been depicted. The chief service the lecturer had rendered was not in pointing out that history was gathered from many sources, pictorial as well as written, but that he had shown to students so many fascinating opportunities of pursuing fresh studies. There would be, no doubt, a growth of useful monographs as the result of suggestions made in the lecture. He would ask Lord Ronaldshay to second the vote of thanks. Every one present would be glad to see him back in this country, looking fresh and vigorous after his highly successful five years as Governor of Bengal.

The Earl of Ronaldshay, G.C.I.E., said he was delighted to associate himself with everything the Chairman had said with regard to the lecture. Personally, he thought one of the most interesting subjects on which it touched was the extent to which the beliefs and practices of Muhammadanism and Hinduism had tended to come together and coalesce as a result of their contact on the soil of India. That, he thought, was a matter not merely of academic interest, but of practical importance, in that it gave some idea of the extent to which a synthesis

between the civilisation and culture of the other two great divisions of mankind—Indians and Europeans—was possible. No one who had had the opportunity of assessing the growing love which educated Indians to-day felt for their past would be likely to under-estimate the importance which that question had upon the relations of this country with India. The lecturer had called to his aid the pictorial evidence of the XVIIth and XVIIIth centuries, and made it quite clear that reverence for saints and ascetics, and the acceptance by the faithful of guides and leaders for the formation of their spiritual life, had become a feature of Muhammadanism in India at that time. He (Lord Ronaldshay) was not sufficiently acquainted with the practices of Muhammadanism in other countries to be able to say whether that characteristic might be regarded as a distinctive feature of Indian Muhammadanism, but he could well believe that its development received a tremendous impetus from contact with Hinduism, because the idea behind it was essentially a Hindu idea. An instance occurred recently in Eastern Bengal of Muhammadans worshipping their saint, entirely in accordance with the traditions of Hinduism, but in a way repugnant to the essential teaching of Islam He should perhaps add that there might have been more policy than piety behind their actions, since the "saint" in question happened to be a notorious local leader of the Non-Co-operation movement. Another striking example of the way in which Hinduism had influenced Muhammadanism in Eastern Bengal was brought to light by the investigations of the Calcutta University Commission It was found that a large proportion of the Muhammadan students at a large school in Eastern Bengal believed in the doctrine of Karma and re-birth, an essentially Hinduistic idea. The lecturer had mentioned the attempts, abortive though they were, of Akbar to bring about a synthesis between Hinduism and Islam, and had spoken at greater length of similar attempts, equally abortive, made by Akbar's great-grandson, Dara Shikoh. It would appear at first sight, therefore, that little in the way of a real reconciliation had taken place between those two great different worlds of thought, practice and belief, in spite of the many centuries during which they had been practised side by side in India. He could, indeed, say without hesitation that any one who had been called upon to take part in the administration of India, in any part of the country where Hinduism and Muhammadanism were practised side by side, must know of the profound antagonism which existed between them, and which was likely at any moment to break out into open violence. He did not think, however, that those who pinned their faith to a synthesis springing up between all that was best in the civilisation and culture of the East and West need be unduly depressed by the apparent width and depth of the gulf which still yawned between Muhammadanism and Hinduism in India. It was by no means certain that the impact between the polytheism and pantheism of Hinduism and the pure and aggressive monotheism of Islam had not left behind it something permanent; it was surely the ferment of ideas created by that impact which found expression in the teaching of two great Indian thinkers of the XVth century, Kabir and Nānak, and it was the new ideas expressed by those two men which in due course produced that great, important and distinctive community, the Sikhs. At any rate, it was arguable that that was so. Sir Thomas Arnold's admirable lecture contained a great amount of food for thought, and he had much pleasure in seconding the vote of thanks to him.

The resolution was then put by the Chairman and carried unanimously.

Sir Charles S. Bayley, G.C.I.E., K.C.S.I., proposed a hearty vote of thanks to the Secretary of State for India for attending the meeting and occupying the chair By doing so, he had paid a fitting honour to the memory of Sir George Birdwood, to whom India and Indian art owed so much. He had also paid honour to the lecturer and to the Royal Society of Arts by his presence that afternoon The then Under-Secretary of State for India, Lord Lytton, had presided over the lecture delivered by Sir Edward Grigg last year, and it was hoped that the precedent thus created would be followed in future: nothing could be more appropriate than that the highest representative of the India Office should preside over these lectures. Sir George Birdwood was associated with India and the India Office for many years, and no tribute could possibly be more gratifying to him than that his memory should be honoured in that way, and that his services in bringing to notice the products, art and ancient civilisation of India should thus be recognised.

Sir Valentine Chirol said he esteemed it a great honour and privilege to second the vote of thanks to the Secretary of State for presiding on an occasion which recalled in the best possible way, and in the manner which would have been most acceptable to Sir George Birdwood himself, the memory of a man who was a devoted friend and lover of India. All those present were very grateful to Viscount Peel for having spared the time from his onerous duties at the India Office to preside over the meeting.

The vote of thanks was passed and the meeting then terminated.

NOTES ON BOOKS.

INDIAN STANDARD LOCOMOTIVES (5′ 6″ Gauge) By H L. Cole, O.B.E., M.I.Mech.E. Calcutta: Superintendent Government Printing, India. 1922 Rs. 5.

This volume forms the two-hundred and twenty-ninth "Technical Paper" issued by the Indian Railway Board, though it is notified that neither the Board nor the Government of India accept responsibility for statements made or opinions expressed by the author. As locomotive development in India is at present entering a new phase, Mr. Cole, who is Secretary to the Railway Board, considers the moment opportune for a review of the main features of the existing standard designs. When those designs were initiated some twenty years ago the fuel requirements of Indian railways were still largely met from the United Kingdom, but with the development of the Bengal fields the importation of British coal was rapidly diminishing Eventually the change over from British to Indian coal became complete. At that time sufficient quantities of the best Bengal coals were available, but since then the fuel position has been entirely altered. The increasing need of the better Indian coal for shipping and industrial, particularly metallurgical, purposes has compelled the railways to rely upon the poorer qualities. "The inevitable corollary to this is that if the efficiency of the train service is to be merely maintained—and we should rather look forward to its being steadily improved—our locomotive boiler design must be adapted to suit the fuel conditions" It is interesting to learn that while the known supply of first class Indian coal is limited that of second class is, to quote the author, abundant and only awaits development. One important factor in the consideration of the question of standardisation policy is specially emphasised by Mr. Cole. "India," he writes, "possesses dangerous land frontiers. It is a necessary insurance, therefore, that provision should exist for the possible necessity of having to effect a great military concentration at any time and at short notice. Locomotives of 5′ 6″ gauge cannot readily be borrowed from abroad and there would be no time to build them. But India cannot afford to maintain an idle reserve of locomotives awaiting such an emergency. The demand when it arises must consequently be met from existing resources, in other words, from various railways all over India" For all the reasons so elaborately set forth it is submitted that "the time is ripe for considering first the possibility of modifying certain existing standards with a view to increasing both capacity and efficiency." The text is illustrated by a large number of plates (photographs) and diagrams.

THE ASBESTOS MINING INDUSTRY OF QUEBEC.

The asbestos deposits of the Province of Quebec, which furnish at present between 85 and 90 per cent. of the world's supply of that substance, are found in a long and narrow zone of serpentine rock which enters Canada from the south, near Lake Memphremagog, and extends in a north-easterly direction, with more or less break, into the Gaspe Peninsula. According to a report by the United States Vice-Consul at Montreal, the workable deposits, so far as known at present, are confined to (1) that part of the zone which extends from Coleraine to East Broughton, for a length of about 25 miles in Megantic, Wolfe, and Beauce Counties, and (2) a small development of serpentine in the vicinity of Danville in Richmond County. There are at present six producing centres—East Broughton, Robertson, Thetford Mines, Black Lake, Coleraine and Danville.

The extreme outcroppings of asbestos ore in the serpentine zone are more than 400 miles apart, the most southerly being near the Vermont border at Mansonville, and the most north-easterly in the Gaspe Peninsula at Mount Albert, in the Weir district, and at Mount Serpentine on the Dartmouth River. A later discovery of an out-cropping of asbestos ore in the Lake Temiskaming district was investigated in 1918 by an official of the Quebec Department of Mines and the presence of veins of asbestos fibre was verified. This prospect is too far from existing lines of communication to offer much interest at present, even if development work on the property reveals the presence of asbestos in economic proportions.

The asbestos extracted from the mines of Quebec is exclusively of the chrysotile variety, the demand for which has within the past few years been greatly augmented by the new uses found for this material.

During 1920 the output of asbestos from Quebec mines amounted to 174,521 tons, valued at 11,758,234 dollars, which is equal to more than 50% of the value of the Province's total mineral production. The corresponding figures for 1919 were 135,861 tons, valued at 10,932,289 dollars.

Practically the entire output of the Quebec asbestos mines is exported, as there is only one concern in Canada manufacturing asbestos products. This factory produces for home consumption and export asbestos slates, shingles, interior and exterior coverings, boards, paper, and undulated asbestos sheets. About 80 per cent. of the asbestos exported from Canada goes to the United States, whence perhaps a small quantity may be re-exported in the crude state. England takes 7 to 10 per cent., and smaller quantities go to Italy, Japan, France, and other countries.

PARAGUAYAN INDUSTRIES AND RAILWAYS.

Paraguay is purely an agricultural and pastoral country and imports almost all of the manufactured goods in use there. Manufacturing on a small scale is carried on in such articles for local consumption as ice, soft drinks, beer, soap, candles, matches, boots and shoes, pottery, tiles, bricks, cigars and cigarettes, sugar, and furniture, and in extractive industries, such as corned beef, jerked beef, quebracho extract, and yerba maté. Owing to the primitive methods in use in most of these lines and on account of their unimportance, hardly any statistics of production are available.

Figures furnished to the United States Vice-Consul at Asuncion by the five principal refineries in Paraguay show that 1920 was the record year in sugar production. They produced 3,639,000 kilos of sugar, 418,917 litres of industrial and rectified alcohol, and 199,101 litres of caña, whereas in 1919 they produced 2,490,397 kilos of sugar, 377,316 litres of alcohol, and 46,350 litres of caña. The annual consumption of sugar in Paraguay is estimated at 3,000,000 kilos. For the first time in the history of that country, sugar amounting to 1,411,037 kilos was exported as follows:—To Uruguay, 980,717; to Argentina, 189,760; and to Spain, 240,560. Paraguay benefited immensely as a result of the prohibition by Argentina of the export of sugar.

Efforts made during the past 50 years to provide Paraguay with means of transportation have resulted in the construction of only 300 kilometres of railway Outside of this line—the Paraguay Central Railway—which connects at Encarnacion, in the southern part of the country, with the Argentine North-Eastern, the country is in the same condition as it was then. In many cases the lack of communication reaches the point of total isolation.

Most of the foreign commerce of Paraguay depends upon the river traffic for its outlet to the sea. In normal times only a small part of the commerce is handled by the Paraguayan Central Railway, and as the river traffic is monopolised by an Argentine company, any trouble in Argentina is bound to have its effect upon the commerce of Paraguay.

The Paraguayan Central Railway Company is planning to construct various branch lines; one from Paraguari to the Misiones in the southern part of the country; another from Ipacary or Pirayu to the Cordilleras northward, and others that will facilitate the problem of transportation for some of the richest and most thickly populated sections of the country.

FUR FARMING INDUSTRY IN CANADA.

The raising of wild fur-bearing animals in captivity for their pelts has been carried on in Canada for many years, but it is only within the last few years that fur farming has become an established industry, according to a recently published official report on this subject, quoted by the United States Consul-General at Winnipeg.

In 1912 and 1913 the Dominion Commissioner of Conservation conducted an exhaustive inquiry into the history and possibilities of fur farming in Canada, and the resulting data, published in 1913, stimulated the industry. The fox has proved the most suited to domestication, although success has been attained in a few instances with mink, skunk, raccoons, and Karacule sheep. The earliest record of raising foxes in captivity comes from Prince Edward Island, where they have been raised for the past 40 years

In 1919 the Dominion Bureau of Statistics began the annual collection of returns of fur farms in Canada. The returns show that 424 fox farms, 3 mink farms, and 2 raccoon farms were in operation in Canada in that year.

The fur-bearing animals on the farms at the end of the year 1919 numbered 8,396, valued at $3,201,388, comprising 7,181 silver foxes, value $3,110,915; 852 patch foxes, value $77,058; 275 red foxes, value $11,345; 1 gray fox, value $150; 1 blue fox, value $120; 77 mink, value $1,685; and 9 raccoons, value $115. There were born in captivity, during the year 1919, 5,048 silver, 510 patch, and 184 red foxes, and 40 mink.

The number of silver pelts sold was 2,134, with a total value of $501,973. This gives an average value of $235 per pelt of silver fox. Patch-fox pelts sold numbered 319, value $21,526 (average value $67), and red fox 164, value $4,586 (average value $28). One blue fox pelt was sold, value $65; 56 mink, value $1,030; and 2 raccoon, value $30. The number of pelts sold in 1919 does not correspond with the number of animals killed for pelts, the sales for the year including some pelts carried over from the previous year, while the pelts of some animals killed in 1919 were not disposed of in that year.

Of the 429 farms reporting in 1919, 244 were operated by individuals, 87 by partnerships, and 98 by joint-stock companies.

THE MINERAL PRODUCTION OF ECUADOR.

The mining industry of Ecuador is limited to the production of gold, petroleum, and salt. The total value of the mineral production is not known, as no official records are kept of any of them, but the production remains approximately the same each year.

Gold is produced at one mine situated at Portovelo, in the southern part of Ecuador, near Zaruma. The control of this industry is based on a contract between the Ecuadorian

Government and the producing company. The production in 1921 was 22,224 pounds of metallurgic precipitates, valued at $774,975, and 1,313 troy ounces of mill bullion, valued at $4,561. The production is disposed of by more or less regular shipments to the United States, the total production being exported. According to a report by the United States Consul-General at Guayaquil, a considerable sum of money has been expended during the last few years to place this industry in a first class condition, and new veins have been located which are said to be richer than those previously discovered. These mines are rather difficult to reach, as both passengers and goods have to be carried on the backs of mules over the tops of the mountains.

The principal petroleum developments in Ecuador are those at the Santa Elena fields on the west coast. The quantity of crude oil produced is about 4,000 barrels per month. The product of the open wells is of much lower grade than that of the drilled wells, the latter being exceptionally high grade. No accurate figures are available, but it is known that all of the crude product is consumed locally, there being two small refining plants in the district.

A recent discovery of oil shale and petroleum was also made in a district north of Guayaquil and more than 100 miles from the Santa Elena fields.

The salt industry of Ecuador is a Government monopoly. The deposits are found in the region of Payana, Punta Arenas, Salinas, Charapoto, Crucita, Latucunga, Guaranda, and the Galapagos Islands.

Deposits of guayaquillite are found in the Canton of Daule, near the Daule River, and occur over a considerable tract of land. The substance is utilized in the manufacture of explosives. No developments have ever taken place in the district, but apparently the mineral exists in commercial quantities. It belongs to the fossil resins and has the aspect of an impure wax Judging from the manner in which the nodules of guayaquillite present themselves disseminated in the alluvial soil along the Daule River, the Consul-General is of opinion that it is not probable that large deposits exist.

THE RAMIE INDUSTRY IN CHINA.

Ramie (*Bochmeria nivea*), also known as rhea and as China grass, is the most important textile plant in China, according to a report from the United States Consulate General in Shanghai. It is grown mostly in the valleys of the Provinces of Hunan, Hupeh, Kiangsi, and Szechuen, to some extent in Kwangtung, and is found in all the warmer parts of China up to 4,000 feet altitude. The ramie from which the finest quality of cloth is made is produced in Kiangsi Province.

Ramie is extremely durable, being of the strongest and finest fibres known. While slightly lacking in elasticity, it is less affected by moisture than any other fibre It takes dye readily, and the fibres have a brilliant, silky lustre. In Japan it is prepared to resemble silk thread and is used for the making of artificial silk garments.

The fibre is employed in the manufacture of gas mantles (for which it is particularly well adapted), also for ropes, lines, nets, underwear, canvas, and other similar fabrics. Experiments have also proved that it can be utilized in the manufacture of paper

The following table shows the amount of ramie fibre exported from China during recent years, as shown by the customs returns :

Countries of Destination	1917	1918	1919	1920
	*Tons**	*Tons**	*Tons**	*Tons**
France.........	432	734	135	179
Great Britain	1,265	1,445	295	1,309
Hongkong	386	642	317	319
Japan	14,958	13,658	13,096	10,303
United States (including Hawaii and the Philippine Islands)	1,337	1,784	25	2
All others	84	45	194	356
Total	18,462	18,308	14,062	12,468

* Short tons of 2,000 pounds each

The total value of the exports* in 1917 was £773,000; in 1918, £936,000, and in 1919, £865,000.

The principal points of original export abroad and to other parts of China are Hankow, Kiukiang, and Yochow, in the order named. The city of Swatow receives the greater share of the ramie fibre exported from other portions of China, this city being the centre of the ramie weaving or China grass-cloth production Swatow and the cities of the Shanghai district receive, approximately, five-sixths of the exports of this commodity. The ramie fibre imported into Shanghai from other parts of China in the year 1919 amounted to 16,180 short tons, of which 2,113 tons were re-exported to other Chinese ports and 13,293 tons abroad

Exports of grass cloth from China in 1917 were valued at £418,000; in 1918, at £507,000, and in 1919, at £994,000. The following table shows the quantity and destination of exports : —

Countries of destination	1917	1918	1919	1920
	*Tons**	*Tons**	*Tons**	*Tons**
Hongkong	101	82	82	113
Japan	68	100	135	131
Korea	820	707	1,472	1,388
Philippine Islands	2	1	3	2
Straits Settlements	61	61	57	82
All others	......	......	......	10
Total	1,052	951	1,751	1,726

* Short tons of 2,000 pounds each.

Kiukiang and Swatow are the original points of export of two-thirds of the entire amount of grass cloth exported from China, Chungking and Shanghai making a distant third and fourth. Two-thirds of the grass cloth

exported from all China is sent to Hankow, Chinkiang and Shanghai, where it supplies the re-export trade and the demand for local consumption.

THE ARGENTINE WHALE AND SEAL OIL INDUSTRY.

The seas of the south and east of Patagonia abound with whales, but very little attention has been given by the Argentinians to the whaling industry. However, there is one Argentine company with a whaling post in South Georgia Island, which is about 1,600 miles to the southeast of Buenos Aires, and about 900 miles to the east of the Falkland Islands. The company has four whaling ships of about 80 tons each operating at the island, and one sailing vessel engaged in the transporation of oil and fertilizer to England. Two more whalers were ordered in Norway for delivery in time for the 1921-22 season. The capital of the company is entirely Argentine; the manager is a Norwegian, and the technical personnel is largely Scandinavian. This company has been operating since the year 1904.

South Georgia Island is in the direct track of the whales coming from the Antarctic Ocean in their migration to the north during the mating season. In the month of November the whales begin to move past the island toward the African coast and across the Atlantic to a point between Brazil and north-west Africa, where the young are born. In their return the whales begin to pass Georgia in February and March. No whaling is carried on at the island from June until October because of the violent winter storms.

It appears from a report by the United States Trade Commissioner at Buenos Aires, that the Argentine whaling company operates entirely from the land, sending out the boats daily from Georgia to distances 40 to 50 miles from the island. The captured whales are brought back to the land. The company keeps a personnel varying from 200 to 1,000, and operates an extracting plant and crushing mill on the island. The annual production is from 25,000 to 30,000 barrels of whale oil and about 5,000 barrels of seal oil, although the production in 1920 was only approximately 20,000 barrels of whale and 2,300 barrels of seal oil. This decrease was due to a strike, and to the restriction of seal fishing by the Government of the Falkland Islands. (These seals are not of the fur-skin variety.)

The company disposes of from 8,000 to 10,000 barrels of oil in Argentine for local consumption, and exports the remainder directly to England in its own one sailing ship. Five classes of whale-oil and two grades of seal oil are produced. Only recently has this company begun actively to produce fertilizer, and the expectations are that the plan will produce 3,000 metric tons of ground fertilizer per year.

THE NATURAL RESOURCES OF SLOVAKIA.

Slovakia is a land of forests, mountains, and streams, about which comparatively little was known before the war. The total area of this part of Czechoslovakia is 25,000 square miles, of which 35 per cent is covered with forests of beech and oak. Every year timber is exported in large quantities. Connected with the lumber industry is the manufacture of toys Toys of original designs and bright colours are a speciality of Slovakia, where they constitute one of the principal home industries carried on by the peasants.

According to a report by the United States Consul at Prague, the mineral resources of Slovakia have hardly been touched During the war a new coal field with an estimated reserve of 124,000,000 tons was discovered in the neighbourhood of Nitra, and is now turning out coal to the value of 8,000,000 crowns per annum. Iron to the value of 40,000,000 crowns is produced annually by the mines of Dobsina; and to the north of Bratislava petroleum has been discovered. Gold, silver, and other precious metals are also mined, in addition to large quantities of antimony, magnesium, copper, mercury, and salts.

No list of the natural riches of Slovakia would be complete without special mention of the numerous springs of mineral water, which make the watering places of Slovakia the rivals of those in Bohemia. There are 30 thermal stations in Slovakia, the most famous of which are Tatranska Lomnice, Strbske Pleso, and Smokovec. The natural waters found at these places contain iron, sulphur, and iodine, in proportions which make them particularly effective for the treatment of nervous complaints, rheumatism, gout, anæmia, etc.

DEVELOPMENT OF POTASH DEPOSITS IN CATALONIA.

Preparations are under way for the exploitation on a large scale of the potash deposits near Suria, in the Province of Lerida, according to a report by the United States Vice-Consul at Barcelona. A Belgian concern is now building an immense plant at Suria, which it is said will have a production capacity more than equal to the total Spanish consumption. To facilitate the transportation of the potash, a railway to Manresa has been constructed, and plans have been completed to extend this line to the port of Barcelona.

The product of the Minas de Potasa de Suria is already being placed on the market, and it is thought that Spain will soon cease to import fertilizers of any kind if production in Lerida is increased as expected. Experts declare that the potash deposits of central Catalonia contain many millions of tons of this mineral.

Agriculture in Spain will be given a great impetus by the development of these deposits.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

EXAMINATIONS.

The results of the Stage I. (Elementary) Examinations, which were held from March 31st to April 12th, were sent to the centres concerned on July 4th. Those of the Advanced and Intermediate Stages were issued on May 29th and June 12th, respectively.

The total number of papers worked in all three stages was 20,973, an increase of 5,289 on the corresponding examination of 1921.

In the Advanced Stage 2,371 papers were worked: 276 First Class certificates were awarded; the Second Class certificates numbered 1,094, while 1,001 papers were classed as failures.

In the Intermediate Stage the number of papers worked was 5,903, made up of 916 First Class and 3,361 Second Class certificates, and 1,626 failures.

Of the 12,699 candidates in the Elementary Stage, 8,629 passed and 4,070 failed. It is hoped to publish the results of the May examinations shortly; the Advanced Stage about the end of July; the Intermediate and Elementary Stages in August.

Two examinations will, as usual, be held in 1923. The first will begin on March 16th and finish on March 28th, the second will be held from May 7th to 17th. The time table has been sent to the Centres.

PROCEEDINGS OF THE SOCIETY.

TWENTY-FOURTH ORDINARY MEETING.

WEDNESDAY, MAY 31ST, 1922.

SIR CHARLES JOHN HOLMES (Director of the National Gallery) in the Chair.

The paper read was:—

THE PROBLEM OF PROVINCIAL GALLERIES AND ART MUSEUMS, WITH SPECIAL REFERENCE TO MANCHESTER.

By LAWRENCE HAWARD, M.A.,
Curator of the City Art Gallery, Manchester.

The subject of the paper which I am to give you this afternoon is "The Problem of Provincial Galleries and Art Museums, with Special Reference to Manchester."

Your Secretary originally invited me to talk to you about the Manchester Corporation Art Gallery, and to illustrate what I had to say by a series of lantern slides. This I readily agreed to do. At the same time I suggested to him that it might be of more interest to a general audience like this if, instead of confining myself to Manchester, I should treat the Gallery in that town as one of a number of provincial institutions, each of which is attempting, with varying degrees of success, to play some part in the artistic and educational life of the community surrounding it. In this way I hope to be able to present to your view, in some sort of perspective, the main aspects of the work that is being carried out, year by year, as part of the normal municipal programme of the city; and whilst doing so, I propose to touch incidentally upon certain problems connected with the nature, growth, and administration of public galleries, upon the right solution of which depends, as it seems to me, not merely the success of any particular institution, but the general well-being of the art of the country.

For it is often forgotten, I think, in London—and here I speak myself as a Londoner—that metropolitan art does not represent the art of the whole of England. The metropolis sooner or later, no doubt, attracts to itself the ablest of the younger men from the country. On the other hand, many not insignificant painters and art workers have refused to migrate to the

capital, preferring to remain provincial in the intensive sense of the word, and gather strength, like Antæus, from their native soil. How far this is to the advantage of all concerned—how far the desire of the moth for the star is good for the moths or the Milky Way—is an interesting and even a practical question; but to attempt to answer it here would take me too far from the more immediate subject matter of this paper. In any case, we shall all, I suppose, agree that whatever the case of a few individual artists may be, and in spite of such means of contact as occasional exhibitions may afford, London and the provinces know little enough of each other.

Londoners, taken as a whole, I think it is no exaggeration to say, are ignorant of the existence of many of the provincial museums and in the case of the larger and more famous galleries are—shall we put it?—somewhat vague as to their contents. And yet it is a common experience of those who are in charge of these institutions to receive enquiries as to particular works from America and the Continent, and to find visitors in the gallery who have travelled from distant parts of the country with the sole purpose of spending their time in seeing the collections.

It is not as if all these galleries and museums lay off the beaten track. Some are easily accessible from the more famous of our Cathedral towns, whilst others are to be found within a stone's throw of popular holiday districts. But those in search of health seldom have time to look for anything else; and even abroad, where English travellers are more deliberately conscientious in seeing the sights of the towns through which they pass, how many of those who have to change at Bâle think of inspecting the Holbeins in the museum, after they have sampled the delights of the Baths and the Buffet de la Gare? How many, even of those whose education has taught them something of the beauty of fine buildings, are aware of the pictures as well as the churches of Rouen, or of the mural paintings by Puvis de Chavannes at Amiens, which lie almost within the shadow of the great Cathedral?

Whether in this country or abroad the traveller must of course learn to take his chance. He must know beforehand what, as Henry James used to say, he is in for. Baedeker and the Blue Guides between them are fairly safe so far as the bigger fry are concerned, but many interesting if unambitious minnows escape the meshes of their nets. In fact even the experts are sometimes being taken by surprise and are discovering treasures hidden amongst the cobwebs of some obscure or moribund museum. For some alas are moribund; some indeed are justly dead already; others are only sleeping with the semblance of death, like the flies upon the walls; some are dragging dead weights that hamper active movement; a few even are going through the laborious processes of creation, subject to the usual handicaps of the new-born infant. The majority are very much alive, though in some cases their vitality is largely spent in fighting various forms of ignorance and prejudice.

If we leave out for the moment all the weaker specimens covered by this summary diagnosis, and consider only a few of those that show unmistakable signs of life and are established on a secure basis, we can take note, up and down the country, of a number of works of art which are of interest and importance, not only to the general public but also to the historian, the student, and the connoisseur.

The paintings of the Venetian School and the Turner drawings at the Fitzwilliam; the drawings of Old Masters at the Ashmolean; the Burne Jones drawings and works of the Pre-Raphaelite School at Birmingham; the paintings by old Masters at Edinburgh and in the Roscoe collection at Liverpool; the old Masters and works of the Barbizon School at Glasgow; the examples of the Norwich School at Norwich; the Wilson's, Millais's and Madox Brown's at Manchester; the English glass and silver in the same Gallery; the historical collection of local pottery at Burslem and at Leeds; the Wrights at Derby; the Miniatures at Bath; and the representative examples of English painting of the last hundred years at Bradford, Newcastle, Dublin, Aberdeen, and other galleries already mentioned—all these are at least noteworthy, and many items would hold their own if shown with the National Collections in London. I have only picked out a handful of cases that occur to me most readily, in order not to worry you by multiplying instances to prove a case which should be obvious, but, like many other things that lie in the way, is often overlooked till pointed out.

There is of course another side to this attractive view of the treasure houses of provincial England. In many of them you will find the main galleries, to say nothing of the corridors and storerooms, blocked with certain ancient leviathans that uncoil their lengths upon the walls in the guise of battlefields, shipwrecked mariners, lighthouses, destructions of Sodom and Pompeii, and so forth. So overpowering are they that it almost seems as though the gallery must have been built up round them, or as if peradventure they had begun life as modest 50 by 40's, and then in that hothouse atmosphere that every gallery generates had grown to life-size scale. Another curious corner of provincial museums may sometimes be found to be adorned with the earlier masterpieces purchased out of Sir Francis Chantrey's notorious Bequest—works which my friends Mr. MacColl and Mr. Aitken brought themselves to the point of doing without, and have allowed ever since to remain a charge upon their generosity.

And apart from picture galleries, a number of institutions still survive in various parts of the country in which armour, pottery, savage weapons, electrotype coins, wood engravings, Indian mats and casts from the antique jostle each other and fight for precedence with samples from a dozen other byways of human knowledge—institutions which I ventured once elsewhere to say are "graced with the courtesy title of museums and are in reality little more than glorified curiosity shops."

These two types moreover—the treasure house and the curiosity shop—are not always entirely distinct. You will often find even in the best of the former some favourites of a previous day banished by a wise directorate to the packing-cases in the cellars—Pandora-boxes from which even hope has managed to escape; and in the darkest of the curiosity shops it is not unusual, as I have said, to light upon some neglected blossom in the dust, some tiny jewel shedding lustre upon its dingy and indifferent companions.

When we begin to enquire into the reasons for the existence under the same roof of a promiscuous jumble of good and bad, the presence side by side of method and disorder, we shall generally find that it is due to the combination of a number of circumstances. I now propose to deal with a few of these, in order to illustrate the kind of difficulties that prevail in the organisation of provincial museums, and the way in which some of them have been solved in Manchester.

Many galleries start with a handicap from the very beginning. Some wealthy citizen with an omnivorous taste for the arts amasses a big collection of miscellaneous objects, and with a fine public-spirited gesture bequeathes them to his native town. The town council, partly in the glow of righteous possession, partly to avoid seeming ungracious by picking and choosing, and perhaps, too, by way of encouraging others to go and do likewise, accept the gift en bloc, and what was confusion in the private house becomes worse confounded in the public gallery. Sometimes the house itself is converted into a public gallery—the Louvre, the Zwinger at Dresden, and the Vatican galleries, to name three examples on a large scale, were all originally private palaces—with the result that even when there is no overcrowding the lighting conditions are frequently bad and the rooms unsuitable for the circulation of crowds of visitors.

The same unwillingness to hurt other people's feelings, combined, to some extent no doubt, with the natural joy of acquisition, is generally responsible for the acceptance of gifts which if offered as purchases would be more closely scrutinized; and purchases themselves may often be made in the artificial heat of momentary emotion, by a committee acting under the influence of what the psychologists call "herd-suggestion", with funds drawn from the gate money taken at a popular exhibition.

In fact the whole problem of purchasing with the various issues it connotes—the question as to what types of work it is desirable to acquire, where such desiderata are most likely to be found, whose business it is to decide whether a work is or is not of the required type, and, if it is, whether it is a good enough specimen of that type—all this has usually received little attention from those on whom the responsibility ultimately rests of spending public money to the best advantage. Even when a satisfactory pragmatic system of purchase has been hit upon, in nine cases out of ten there is little space available for displaying recent acquisitions. In many towns, moreover, the powers that be have ordained that an art gallery, a science museum, and a library (all three often controlled by

the same individual), are to elbow each other within the same four walls, art and science usually sharing the honours of the upper story, whilst books are relegated to the cellars; so that even when the visitor has run the gauntlet of the newspaper files and the card catalogue he is in delightful uncertainty whether on turning the corner in the corridors upstairs he is likely to be confronted with Staffordshire pots, stuffed birds, or portraits in oil of the leading local celebrities.

Nevertheless, these and other difficulties that waylay the steps of those who have to administer public galleries and art museums are not by any means insurmountable. Each gallery, in point of fact, seems to find itself able to tackle successfully some of the problems of good organisation even if others have to be left untouched. What is wanting is some general agreement as to first principles, some common understanding on the part of those most nearly concerned, to enable the different units all over the county, whatever their particular aims, at least to be animated with the same ideals.

Manchester is, I think, fortunate in many respects in having been able through a variety of causes to advance along a more or less definite pre-determined line, as the result of which she has forced circumstances to give way to her instead of allowing them to be one of her conquerors. And here let me say in parenthesis that if I quote what has been done in Manchester rather than in other centres, it is not because I wish to make invidious distinctions between equals; still less do I suggest that what Manchester thinks to-day has not been thought of yesterday, or even a week ago, by all her intellectual rivals. It is simply that I happen for obvious reasons to be better acquainted with conditions there than elsewhere and because it was, after all, of Manchester that your Secretary asked me to talk to you.

When I said just now that the Manchester Gallery had moved on fairly definite pre-determined lines, I did not so much mean that its policy to-day is the policy that was laid down at its foundation a hundred years ago, as that the aims of the group of men who first interested themselves in establishing a gallery in Manchester have been constantly borne in mind throughout its history whatever modifications of principle or detail may from time to time have been introduced. The Gallery itself, a charmingly proportioned classical building designed by Barry, was originally one of those institutions for the promotion of the Arts, Literature, and Science, so many of which a few years later sprang up under the auspices of the cultural twins Kunst und Wissenschaft, in the days when good Prince Albert stood behind the throne. Science, however, soon became less prominent than the Arts in the Institution's programme, presumably because of the existence of purely scientific bodies in the town, and was eventually dropped entirely; so that when in the eighties the Governors decided to offer the building with all its contents to the city, it was no miscellany of art and natural science that the town inherited, but a collection of reputable pictures, together with a tradition of supporting the fine arts by holding periodical exhibitions, lending rooms to the local Academy of Painting for teaching purposes, and showing the citizens examples of good current art obtained by purchase and by loan. When the Institution was transferred to the Corporation and maintained out of the city rates, one condition was imposed by the Governors, namely, that for a period of twenty years the sum of £2,000 should be spent annually in the acquisition of works of art. The condition was, of course, accepted and on the expiration of the term agreed upon the same sum was voted year after year by the City Council, and has been continued with a brief voluntary break during the war until to-day. The money, I should add, does not fall into the common fund, but accumulates, if it is not exhausted at the end of the financial year.

To the works which have been gradually acquired by purchase have been added a number of most generous gifts and bequests, which would have been more numerous still but for the inadequate accommodation that the present Gallery offers. Local collectors, as is now known, have refrained from leaving to the city treasures which ran the risk of being stored away out of sight, or of being shown under such crowded conditions that they could not be properly seen. More than one collector has indeed made his bequest conditional on a new Gallery being built within so many years, in the hope of thus stimulating public opinion. Others have shown themselves more simply generous, and through them the town has been enriched

with good collections of English Pottery, glass and silver, Chinese and European porcelain, and mezzotints besides, of course, paintings and early English water colours. These watercolours are not only very choice in quality; they also cover the whole range of the art from the early topographical draughtsmen down to those who are living to-day. Indeed the watercolours belonging to the Corporation taken with those at the Whitworth Institute (a public Gallery administered by Trustees), make Manchester richer in the English School than any town in the kingdom except London.

These and other gifts to the city have brought about a state of congestion in the Gallery that renders it absolutely imperative that new quarters should be found. At present there is no way of showing the glass, silver, and porcelain, except by filling up the floor space of the Gallery with cases which have to be crowded together and prevent the visitor from obtaining a general view of the pictures on the walls behind. But for the war these new quarters might already have been provided. As ft is, the City Council has decided that on the large site in the centre of the town where the Infirmary once stood, a new building shall be erected in which provision will be made for housing not only the fine, but the applied arts, and those examples of modern textiles, ceramics, wood and metal work which demonstrate the application of good design and workmanship to the articles of every-day life.

The only possible advantage of having an over-crowded Gallery such as ours, that I can think of, is that every fresh acquisition involves moving something else in order to give it a place. (The advantage is, you perceive, not peculiar to the conditions). To move an exhibit, especially if it is a popular one is, I am convinced, a good thing to do. If the public never sees anything but the old familiar faces exactly where it is expecting to find them, it soon begins to take them for granted and eventually fails to notice them at all. Even when it is not necessary to make way for fresh acquisitions, the permanent collection should, if only on these grounds, be rearranged from time to time within, of course, reasonable limits. For the same reason the holding of temporary exhibitions; though it may involve dismantling a portion of the collection, is to be advocated as providing a stimulus quite apart from that of the Exhibition itself.

During the last ten years, as many as sixty exhibitions of one sort or another—paintings, drawings, etchings, Chinese porcelain, modern domestic pottery, textiles, cottage furniture, printing, theatrical designs, American architecture, and so forth—have been held in the Manchester Gallery; and we were recently responsible for a demonstration of what can be done to-day in the way of cheap and simple furnishing, which was carried out in one of the new Corporation houses in conjunction with the Housing Authorities and the local branch of the Design and Industries Association. This demonstration was seen by nearly 30,000 visitors, and during the ordinary exhibitions in the Gallery the average daily attendance is over a thousand. These figures are, I think, proof enough that a series of exhibitions will repay the time, trouble and money spent upon them, in the number of people that they attract to the Gallery; and it is noticeable that those who have once been interested in a particular exhibition, and have come to the Gallery for the first time, perhaps, to see something they have been told will appeal to them (it is often something relating to local conditions or requirements) will come back again in the expectation of finding more things likely to prove attractive. In other words, once establish a live policy within the walls of the Gallery, and you have secured your public, which not only consists of an aggregate of casual visitors, but constitutes the soil in which are nurtured students, artists, craftsmen, and even potential benefactors.

Exhibitions such as those I have described, should not, I think, be left to speak entirely for themselves. Apart from the publicity gained by dignified and clearly printed posters, it is advisable to issue small catalogues and leaflets describing their main features and sell them, not with a view to making a profit for the Gallery, but at a price which will just cover the cost of production; and it is often good policy to arrange for special lectures to be given in connection with some temporary exhibit, whether of works on loan or of those from the permanent collection. A recent lecture, for example, by Mr. Hobson, of the British Museum, on jade, on the occasion of a loan to the Manchester Gallery of a choice collection from a local collector, and another on

Mezzotint, from Sir Frank Short, during the exhibition of a large bequest of examples of the English engravers of the 18th century, drew very large audiences, and from the stimulus that was thus given to collectors and enthusiasts (who were brought into contact with the lecturers and could follow up their points by studying the objects in the exhibition, that illustrated them), had a wider and more permanent influence than if they had been given casually apart from their context.

Numerous lectures on various subjects connected with art are given in Manchester during the course of the winter months, not only at the Central Gallery, but also at two of the Branch Galleries that are situated in populous districts, and a very large and varied collection of lantern slides of paintings, statuary, engraving, architecture, and so forth, is at the disposal of any accredited borrower. Arrangements are, of course, also made for conducting parties of visitors round the Gallery, usually after a preliminary talk has been given on the scope of the collection, and a few hints as to how to look at pictures.

A more purely educational piece of work has also been carried out in conjunction with the Manchester Education Committee. Owing largely to measures which were adopted in war time, to find occupation for the children whose school buildings had been converted into military hospitals, and who had, therefore, to share a building with another school, some 600 children a day are now given very elementary talks on the contents of the principal galleries and museums in Manchester, by teachers specially trained and appointed for that purpose. In this way the young people (the citizens to be) learn from an early age to regard a visit to a Gallery as a perfectly normal experience, and very soon they not only enjoy coming themselves, but they return in their leisure hours with their friends and parents.

The accessibility, for purposes of study, of objects in the collection which are not actually on exhibition, is a problem which the lack of space, that I have already referred to, has made it very difficult for us to solve. It is no consolation to think that even at the Victoria and Albert Museum there are practically no study rooms for research work, and that in the British Museum the Reading Rooms and Print Room have nothing corresponding in other departments. In preparing the designs for the National Museum of Wales at Cardiff, which is now in process of being built, the provision of Study and Storerooms was carefully taken into consideration and the examples set by this great Institution will, it is to be hoped, be followed by all who are in the fortunate position of looking to the future for their museum, and not to the past.

Another first principle in museum organisation, on which one would expect common action as well as common agreement on the part of everyone concerned, is the necessity for setting out all the exhibits in a way calculated to show them to the very best advantage. I do not propose to speak of technical device of arrangement, lighting, and so forth. I only wish in a general way to emphasize the fact that many provincial museums are at a great disadvantage from the nature of the rooms provided, which even when the museum has not been adapted from a palace or a private house, are constantly too dark and too large. Nothing is so depressing, so lowering to the vitality of a good picture, as a dark room or one which overwhelms the canvases with a vast expanse of wall running up through frowning cornices to the stately pleasure-dome the architect so thoughtlessly decreed. One of the most needed, and, if I may be allowed to say so, one of the most successful reforms that our distinguished Chairman has carried through at the National Gallery has been the brightening of the walls and the apparent lowering of their height by the most skilful use of the office paint brush, and by what might be roughly described as architectural camouflage.

In point of fact, the various devices we have been considering for overcoming the numerous difficulties of organisation with which galleries and museums are confronted are based on two fundamental axioms: "Show things to the best advantage," and "Have only the best to show." With the first of these I have already dealt. It only remains for me to treat very briefly the problem of high standards which it is the primary duty of all who are directly or indirectly connected with the Gallery consistently to maintain.

The simplest plan of all for showing only the best in the Gallery is to withdraw from exhibition everything which does not reach a certain standard. This may be a little

drastic for some institutions, but I know of no better way. Works of art are like human beings: they are affected by the tone of the company they keep. Fine work in mediocre surroundings, so far from shining all the brighter by contrast, will almost seem to sink to the level of the second-rate, or whatever their lowest common multiple may be.

Purchases I will come to in a moment. As to gifts, the task of refusing those that are poor in quality is not in reality so difficult as it may appear. A good deal depends on the donor and nearly everything on the way in which the matter is handled; but it must be rare, I think, for a director to find a would-be donor so impervious to reason as not, sooner or later, to be brought to share the view that when a gift is accepted by a public gallery the donor is often honoured at least as much as the institution.

It is a more difficult matter in most galleries to maintain the same high standard in the purchases, because, whereas the scrutiny of gifts is often left to one individual, it is very rare to find decisions as to purchases not made by an entire Committee. Now, Committees, I suppose, have their purpose in this teleological world, and may even function well, expecially when the constituent members of it refrain from attending meetings. In the matter of purchases, the function of a Committee should be to decide such questions as whether any money is to be spent on buying works of art at all, what type of work it is desirable to add to the collection, what should be the maximum spent at one time, and so on; its business, that is to say, is to decide matters of general policy. But a decision as to any specific work, more particularly a decision as to the relative merits of several different works, requiring, as it does, expert knowledge and taste, should never be made a matter of collective judgment, with its inevitable corollary of divided responsibility. Even in the unlikely event of all the members of a Committee being trained judges,—*quot homines*—their taste will vary, and if they are intelligent and strong minded, they are bound to differ about works of primary importance, and will, indeed, often only be able to come to an agreement about those that are not of sufficient interest either way to rouse their passions.

The individual may make mistakes; (Crichton himself, had occasional lapses); but if his mistakes are rare they are more than compensated for by his sound judgment; if they are frequent, the remedy is to find another individual to take his place.

Even for the conduct of the general business that has to be transacted by a Gallery Committee composed of city councillors, it will, I think, often prove advantageous to co-opt a few independent advisers, chosen for their special knowledge or for their interest in particular sections of the collection. The constitution of the Committee may not always admit of this, but a way out may sometimes be found by the device of delegating different pieces of specific work to Sub-Committees, and then co-opting on to these smaller bodies members to act in what is quaintly known as an advisory capacity.

Local interest should, in fact, be used officially or unofficially, wherever it is required. The way in which workers in various special fields are ready in a place like Manchester to give their time and put their knowledge at the disposal of those who are ready to make use of it, is very striking, and, of course, by no means peculiar to Manchester. Another sign of the spirit of friendly co-operation prevailing there, is to be found in an agreement that has been arrived at by the various galleries and museums in the town to keep each other informed, by the machinery of occasional meetings, as to their respective lines of action and future development, with a view to preventing waste and overlapping in matters either of detail or of general policy. Quite recently, too, a Federation has been formed of the various local art societies which, it is hoped, may be able to influence public taste by bringing a body of united opinion to bear wherever it may be required.

Such co-operation as this amongst the purely local galleries, has a parallel in the relations between the National and the Provincial collections. If more has not been done to make the National Collections available to the nation, as distinct from the inhabitants of London, it is largely, I think, because the provincial galleries have not always realised how ungrudgingly those in authority in the great National Galleries and Museums will impart their knowledge and render assistance in a variety of ways to their provincial colleagues out of the abundance of their own treasures.

You will see from what I have said this

afternoon, that the task of administering the provincial galleries is both exacting, because of the difficulties with which many of them are contending (under conditions that in the smaller towns amount practically to spiritual isolation) and exciting, owing to the possibilities inherent in the spirit of local patriotism. The force of this local patriotism is not always, I think, quite appreciated by those who have never lived outside London. It is a very remarkable moral asset in the life of a community, both for good and, on occasions, for bad; and it is this force which makes it so much easier to get things done, as the phrase is, in the provinces, than in London. Londoners—and here again I speak as a Londoner myself—are nothing if not critical; in the provinces purely destructive criticism is regarded as waste of time, and the spirit of humorous toleration, born of cynical detachment, is not in the least appreciated. These gaps in the psychological outfit are, I think myself, a loss in the case of individuals, but a gain when you are dealing with people collectively. However that may be, there can be no doubt that there is a vast fund of idealism in the big provincial towns which is waiting to be turned to account, and which is the more easily accessible from the fact that it is localized and concentrated, the area to be covered being smaller than in London and the population in it less fluctuating and therefore more susceptible to repeated impressions.

This, in terms of the subject matter of our paper, means that provincial galleries and art museums scattered up and down the country, if only they know how to use their opportunities and are given a fair chance of putting their knowledge into practice, can become a really vital influence in the town, setting standards of reference for students, artists, and craftsmen, and acting generally as cultural centres for the whole community.

The slides I shall now proceed to show you of some of the more interesting of the treasures in the Manchester Gallery, would by themselves, I think, have been of little use as an illustration of the work that is being carried on there, and still less as an index to the potential influence of provincial galleries in general, without some such sketch as I have attempted to give you of what has been done in the past, and what it is hoped by the Municipal Authorities to do in the future, to give art its rightful place in the daily life of the people who have to live in the huge commercial capital that lies at the very heart of industrial Lancashire.

DISCUSSION.

THE CHAIRMAN (SIR CHARLES HOLMES), in opening the discussion, thought Mr. Haward must be esteemed a lucky man because he was able to speak of provincial museums with an air of optimism, which he had always noticed accompanied success. He thought it was a great thing that an important Museum and Art Gallery like that of Manchester should be in the hands of an optimist, both for the reason he had mentioned, and also because optimism generally carried with it what might be termed a live policy. Museums and art galleries, whether provincial or metropolitan, were perfectly useless unless they were alive, and he was very glad to think that the policy of recent years, which owed so much to the advocacy of Lord Sudeley, particularly the establishment of lectureships in various museums, had not only been generally adopted, but had proved that Lord Sudeley was perfectly right in the interest it had aroused. He was specially pleased that Mr. Haward had mentioned that lectures were a part of the regular curriculum of Manchester, because he was sure that the establishment of lectureships was the means by which any provincial corporation and any metropolitan body would obtain the best use from their museums; indeed, it was only by those means that they would obtain full use of their collections. Mr. Haward had also pointed out that museums, if intelligently handled by means of lectures and so forth, became nuclei of culture and education, and that visitors who were attracted perhaps once by a lecture brought other visitors in their train He need hardly say that the benefits visitors derived were not limited merely to the study of the objects the museum contained or the immediate impression that the visitors derived from them. What was far more important was that the people who came should be interested in something which had a permanent relation to history, whether of their own city or their own or any other country. At present we lived in a democracy, which was in perpetual danger from want of knowledge on the part of the voting population. He could not conceive any way in which the great democracies of this country could learn to administer the powers that lay in their hands half so well as if they went regularly, as a part of their regular education, to museums and galleries, and thus were brought into touch with the great achievements of the past, so that they recognised that they were not merely dwellers in this or that village or city, but were part of a universal citizenship which had

a history of many thousand years. If thereby even only a small proportion of them learned something of the history of the past they would be a great deal better able to deal with the affairs of the day than he often feared, sometimes after attending debates in the House of Commons, was the case at the present time He was very glad to see that side of museums was one on which the author placed great emphasis. It had been developed recently in London to a considerable extent, but he would like to see it a regular feature in a great many provincial museums, too. He did not think, however, a live policy of that kind would be adopted in a great many provincial centres until provincial municipalities recognised that the headship of their museums and galleries was a post which deserved the most careful consideration and selection. During the last ten years, since he had been in London officially, he had often been consulted informally with regard to provincial appointments, and in some cases he had been shocked by the views that men important in their own places appeared to take of those positions. The decisions in one or two cases known to him were nothing short of deplorable. The idea that an important gallery in a great industrial centre could be managed by some employee of the corporation, who had hitherto been assistant librarian and who had perhaps married the daughter of a town councillor, was a great deal too common, and until members of provincial corporations recognised that they possessed in their museums institutions which in their way had almost as great an educational function, and might be almost as great a credit to the city in which they existed as their universities, the grants that they gave were in great danger of being wasted, and museums would remain in the condition to which the author had referred. There was another point of view, from which it appeared to him that provincial corporations were short-sighted. The author had referred, very rightly, to the necessity of maintaining a high standard of exhibits. It was well known that when a gallery had a reputation for having a low standard of exhibits nobody thought of going near it unless fate left them at the station with two hours to wait. On the other hand, a museum in which a high standard had been maintained was an institution which not only all connected with the subject in this country were obliged to visit, but that students even from the Continent had to visit if they were making a special study of any particular subject. Bearing in mind the standard of a good many Continental collections, it would be recognised what an asset they were to the cities which contained them. It was felt to be a mistake if a place was not visited which had a famous gallery or a famous museum. That was the sort of feeling he would like people in this country to have in connection with provincial museums, and it was a great pleasure to him to know that there were present at the meeting two men at least who were identified with collections of that quality. But collections of that quality would never be obtained unless great care was exercised in the choice of the director. If that care was exercised, the director gained the confidence of the municipality with which he had to deal, and in a very few years was able, or ought to be able, to do what he pleased with his committee, so that when he wanted an important thing for his museum he was able to get it at once. The difference in salary between a good man and a cheap man was repaid ten times over to the city if it would take the trouble to get a good director. Lastly, in connection with the need of high standards, he desired to make a few remarks with reference to that depletion of the art treasures of the country which was occupying so much of their thoughts at the present time. It had often occurred to him that in cases in which the starved metropolitan museums could not intervene to save some of the masterpieces that were going out of the country, there were, in provincial centres here and there, men who, if they liked, could "plank down" the price and not feel is very seriously. He looked forward to the day when one or two of the fortunately directed provincial centres would relieve institutions like his own from the discredit which attached to it when from time to time first-class masterpieces, which ought not to leave the country, did so. He did not see why some of the provincial galleries should not, under the best guidance, do even better than they had done in the past. Since space even with them was always a consideration, it was a very much better policy for them to secure ten first-class masterpieces than 100 paintings which were just short of being masterpieces. They took up much less room, and the ordinary admirer of paintings and art had to stop at that town and visit the gallery, whereas he would not do so to look at 100 second-class paintings. In that way the credit of the collection, and he believed in time the reputation and income of the city, would be increased.

Sir Whitworth Wallis (Director, Corporation Museum and Art Gallery, Birmingham), said he desired to endorse what the author had said with regard to the important question facing most provincial museums in regard to the appointment of suitable directors. During his 37 years' experience in the provinces there was hardly a provincial gallery or museum in England, Scotland or Ireand that he had not visited at different times, and if these museums were to become the great educational asset they should be a very different type of director or curator would have to be appointed from those who had occupied the position in the past. It was necessary to have men of far broader views, with far more knowledge of art, greater general culture, proper art training both at

home and abroad, than some of the men who were appointed at present. Sir William Flower, the Director of the Natural History Museum, stated in his presidential address to the British Association many years ago, that the life of the curator was the life of the museum, and that the life of the museum was the life of the curator; and that no museum would ever be a great success in this country unless the curator or director occupied more or less the position of dictator, one who would not be always guided by the fancies and the likes and dislikes of different members of the governing body. There was no committee like a committee of one, that one occupying the position of chairman, and he was a great believer in that policy. He also believed that if the curator of an art gallery once obtained the confidence of his committee they would accord to him a very considerable measure of dictatorship. Another important point was that so many of the museums in the country had no definite policy; they were a mere *omnium gatherum* of popular pictures—popular pictures of which the public tired, and no use whatever to the art student or collector. He visited one such museum on the seaboard some time ago, and could not help remarking that if they went on collecting pictures long enough they would have to roof in the whole city! In his opinion it was desirable in provincial museums more or less to specialise. Certainly in great cities like Liverpool, Manchester and Birmingham the museum should have a *raison d'etre*, and if they specialised they would draw the public from a distance. They would come to see, he would not say ten masterpieces, but they would come to visit collections formed with a definite purpose. He hoped he would not be thought conceited if he mentioned his own gallery, which he was appointed to when the collection was housed in a small gallery at the Free Library. The present buildings now contained seventeen picture galleries, a great Industrial and Decorative Art Museum, bearing upon the industries of the City and district, a Museum of Classical Casts, and a Natural History Department. Towards the new buildings one Birmingham citizen bequeathed £50,000. Birmingham made up its mind to specialise, and with all due deference to the Tate Gallery and other galleries, he advised those who wished to study English pre-Raphaelite art to go to Birmingham for that purpose. Americans not only visited the town in which he resided, Stratford-on-Avon, but they also visited Birmingham to see the most complete collection of pre-Raphaelite pictures and drawings, the early Millais's, the Ford Maddox Brown's and the Rosetti's, together with the most important collections of works by Birmingham's sons, David Cox and Burne Jones. Definite collections acted as a magnet. They not only attracted visitors, they also induced gifts from people interested in certain phases of art. The whole of the collections at Birmingham, valued at £300,000, had been presented, and had never cost the ratepayers a penny, except for the upkeep of the buildings. During the last 35 years, Birmingham had received in that way, gifts worth many thousands of pounds from people in no way associated with Birmingham, who were simply collectors of similar works by artists whom they wished to be represented in the gallery. With regard to the question of the buying or accepting of works of art, he would like to see inscribed over the room of every curator of an art gallery: "It is not what you accept that will make your art gallery; it is what you have the courage to refuse."

Mr. J. Bailey (late of Department of Circulation, Victoria and Albert Museum) said he desired to emphasise the point the author had mentioned in regard to the constitution of the Committees that dealt with Museums and Art Galleries. Ordinary Town Councils did not attach very much importance to the Museum Committee. Generally, if a man was newly elected to the Council he was put on the Museum Committee, because he was not looked upon as being a sufficiently good man to deal with drains and things of importance. If, as sometimes happened, the Museum was placed under the Parks and Cemeteries Committees, all hope might be abandoned! The average Town Councillor was not the sort of man to deal with Museums, and he could say that with the more knowledge because he happened to be a Town Councillor himself. Members were frequently selected for the various Town Council Committees because of the qualifications they did not possess. In his own particular case, after doing 45 years of educational, including Museum, work, he was appointed a Member of the Committee dealing with the diseases of animals It was necessary that that state of affairs should be rectified if progress was to be made. He agreed with the author that the proper course to adopt was to elect a certain number of people from outside who really knew something about Museums and education. With regard to the choice of a Curator or Director, he remembered that the first Museum that he visited in his official capacity was in one of the lesser cathedral cities. He there saw a man washing the steps of the entrance, and enquired of him where he could find the Curator. The man said to him very proudly: "I am the Curator!" On asking the man to be kind enough to show him the arrangement of his collection, he looked at him as though he thought he was an idiot escaped from Bedlam, and then replied, "The arrangement of my collections?—I put 'em in places that fit 'em!" One could quite imagine what sort of *omnium gatherum* existed in that city, where, curiously enough, the Committee were composed for the most part of dignitaries of the church, who ought to have known better. The author had pointed out that the Metropolis

was not England. There was a great deal illustrating arts and crafts at the hub of the universe, and possibly not sufficient of it was getting to these industrial centres, which were more or less interested in those matters. Having been in charge of the circulation of collections at the Victoria and Albert Museum for some years, he could fully endorse what the author had said in that respect. He thought the time had come when the central institutions were getting almost more material than they could deal with, and that the smaller local ones were more or less starving. That state of affairs should be put right by means of co-ordination of effort between the various institutions which were lending in some form or other works of art to Provincial Museums. The Victoria and Albert Museum, the Natural History Museum, and the National Gallery, were rendering great assistance by lending some of their collections but it was not always the case that the curator who was placed in charge of those examples in provincial centres possessed that knowledge of the necessity of protecting them, for instance from sunlight, which he ought to have before being placed in charge of works of that character. In his opinion, the work of the Central National Institutions should be co-ordinated, and there should be one central Circulation Department dealing with all the Provincial Museums, keeping a general eye on them and assisting them upwards. Such an organisation would be in a position to give a Curator considerable leverage in rejecting unsuitable examples. He remembered when visiting one Museum at a sea-port town, seeing some wool pictures, and on enquiring from the Curator why he kept such things, he was told that they were given by a Town Councillor! There was still room for improvement, and for really great assistance from the centre to the outlying Museums, and he hoped that in the near future some co-ordinated scheme would be adopted which would enable them to give that further assistance which the local Museums required.

PROFESSOR ARTHUR M. HIND (Slade Professor of Fine Art, University of Oxford), said that at Oxford he was faced by a very difficult problem, because there was no really serious study in the history of Modern Art, except in music. An attempt was being made to introduce some definite study of the subject as part of a degree course. That appeared to him to be of very much greater importance than trying to establish a large and ambitious school of art, because the aim of a University should be essentially humanistic. Subjects like engineering having been introduced, it was perhaps inevitable in the end that a practical study of architecture and other arts should follow, but he did not think that this should be the first aim of a University. It was his desire to see a study of particular portions of the history of art—for instance, the history of Renaissance art and outlines of the History of Architecture—introduced into the History School. Difficulties would be involved, as probably the great majority of the Board of the History Faculty at Oxford would be against innovation, the argument being used that such subjects were entirely different from the special subjects that had hitherto been taken. The question of improving the status of Keepers of Provincial Galleries was linked very closely with the problem, and was of great importance from the point of view of art education in general. It was probably from the Universities that the men most suited for those positions would be obtained. If the proposals were adopted, such men might be advised to take a History Course, together with some special subject in the study of Modern Art. But it would hamper the possibilities of such courses if the men knew that there were no appointments open to them afterwards, in connection with the study they had gone through. Personally, he would be glad to hear the opinion of Provincial Directors on the subject of the possibility of the Universities helping in connection with the education of men for the positions they occupied. It was also exceedingly important in his opinion, that greater co-ordination between the British Museum, the Victoria and Albert Museum and other bodies of that kind should be inaugurated. There had always been a feeling, so far as the Provinces were concerned, that they should be generous to contemporary art and try and buy the works of living painters On the whole, he thought that was more a matter for private purchasers, and that the important point in the making of a Provincial Gallery, as in a national collection, was to keep up the right standard of works of art When it was impossible to obtain masterpieces by great masters they should endeavour to obtain representative collections of engravings and drawings, because in that way the Provincial Museums could, in many cases, keep the right standard and at the same time keep within their means.

MR. ARTHUR SEVERN thought that in all provincial exhibitions a picture of a great event that had happened in or near the place ought to be well shown. He was disappointed to see, a year ago, in the beautiful Newcastle Gallery, a picture by John Charlton, depicting a lifeboat which had been brought for miles by 150 women, placed in a dark corner. In the case of such a picture, even if it was not a very good one, the people of the town ought to be able to see it properly.

MR. A. F. KENDRICK (Department of Textiles, Victoria and Albert Museum), said it seemed to him the author had gone a good way towards solving the problem of Provincial Museums, the outline he had given for their activities being an admirable one. It had to be borne

in mind, however, that the problem of Museums was insoluble by any generation. Nothing much could be learned of astronomy if it was possible to see only a few hundred thousand miles, and as Museums had to survey the intellectual activities of men from the beginning of time, their scope was too wide for any final solution. They could only adapt the problem as it appeared to them to the conditions of the day in which they lived, and to the locality which they served. It was impossible for all the Provincial Museums to do what Mr. Haward had done at Manchester, and the Chairman had done in Trafalgar Square. The Museum problem was one of compromise with the conditions of time and place, and each Director must do the best he could. When Mr. Bailey referred to the Curator whom he saw washing the steps, he thought Mr. Bailey was praising the Curator. He heard the other day, that when somebody went into the National Gallery he saw the Director white-washing the walls He respected any Curator who would act in that way if the occasion called for it. The principal point he wished to make was that it was necessary for them to turn their hands, in the very unfortunate circumstances that existed in Museums at the present day, to adapting them to the times in which they lived

MR. W. S MARCHANT said that in the purchase of modern works Provincial Galleries were in competition, not only with the private collector, but also with the dealer, and if they were to attempt to obtain the finest works of the present day they must be in a position to secure them as against the dealer or private collector. It was part of his duty to receive occasional deputations from Provincial Galleries, and he noticed that one of the great difficulties experienced was the impossibility of obtaining unity in those purchasing Committees. One question which required study was the exact status of the Curator and of the Art Committee with which he was connected. He had never yet had experience of a Provincial Committee in which the Director was the dictator, and disputes most naturally arose where a number of people had to give their opinions. Some years ago he spoke to a prominent Member of the Contemporary Art Society on this question of buying, and told him that until they nominated a purchaser and gave him authority to buy just what he liked, up to a certain amount, they would never be able to compete in the market with the private collector or dealer. Apparently this system was afterwards adopted.

MRS. JAMES DUNCAN, after thanking the author for his paper, stated that she thought the most important point it emphasised was the necessity for co-ordination. In a big town like Manchester it would be desirable to have two Galleries, one containing the historical works of great masters and another containing modern works. She suggested that the Gallery containing the modern works should not be a permanent one, but that travelling collections should be formed which could be sent round the country.

THE CHAIRMAN, in proposing a hearty vote of thanks to the author for his excellent paper, said he only desired to say that, to the best of his recollection, the story which had been mentioned about his having used a whitewash brush in public in the National Gallery, was apocryphal.

The resolution of thanks was carried unanimously, and the meeting terminated.

THE CZECHO-SLOVAK GLOVE INDUSTRY.

Before the World War, the glove industry in Austria-Hungary is said to have given employment to some 30,000 workers, and to have reached an annual average production of 1,500,000 dozen pairs, 80 per cent. of which were exported to other countries. Owing to the low price of raw materials, it is said that fully 50 per cent. of the profits remained in the country in the form of wages

Although about 80 per cent. of the former Austrian glove factories came within the boundaries of Czechoslovakia when the new Republic declared its independence, near the close of 1918, glove production in Czechoslovakia has decreased 8 per cent. of what it was before the war.

According to a recent report by the United States Consul at Prague, the present unfavourable situation in the industry is said to be due to the difficulty of competing with Germany and Italy for foreign markets. In Germany the cost of labour is about 25 per cent. lower than in Czechoslovakia, and in Italy it is said to be even less. It naturally follows that German and Italian gloves of equal quality are in greater demand abroad.

The trade is further embarrassed by a shortage of skilled workers. In certain sections of Bohemia, the glove factories suffer from a lack of skilled labour to such an extent that hundreds of machines are no longer in operation and the pre-war production of 2,800 to 3,000 dozen pairs of gloves a week has dropped to about 200 or 250 dozen pairs.

The principal export districts for the glove industry in Czechoslovakia are Prague, embracing the cities of Tabor, Lysa, and Tuskov; Rudohori, embracing Kadan, Abertany, Berinky, Jachymov, Blatno, Hroznetin and Wiesenthal; Brno and Losice in Moravia; and Fryvaldov in Silesia. These districts show many variations with respect to the manner of production and the kinds and qualities of gloves produced. Washable gloves are principally manufactured at Kadan, in the Rudohori district, and kid

gloves in the mountains. There is a considerable domestic consumption of kid gloves. In Prague the production is varied, a part of the output being finished at homes in Rudohori. Before the war, about 80 per cent. of the glove export trade was centred in the Prague district, the factories of which accounted for some 1,000,000 dozen pairs of the annual total production.

Of the total exports of leather gloves during 1921, amounting to 179,455 pounds, 112,640 pounds went to the United Kingdom, 18,260 pounds to Austria, 11,660 pounds to the Netherlands, 7,920 pounds to the United States, and smaller amounts to other countries.

PEPPER IN SARAWAK.*

Pepper growing, which used to be one of the chief industries of Sarawak, is gradually dying out chiefly on account of a disease for which no cure has yet been found.

It is grown on red loamy soil and will not flourish in clay or sand

The Pepper vine was cultivated in the Upper Sarawak district and at Lundu and Simatan; these are the old plantations; large quantities are now grown in the Batang Lupar and Rejang districts, but the plantations are not sufficient to replace the large districts which have died out in the Upper Sarawak district

The amount exported in 1911 was about 2,800 tons as compared with just over 1,000 tons in 1920.

PLANTATION.

There are two kinds of vines grown in Sarawak, the broad leaf vine and the small leaf vine

Vines are planted from cuttings in soil prepared with burnt earth, in the months of August and September; the cuttings are planted 4 to 5 feet apart and they require shading until they begin to shoot.

When they have been planted about 8 months a belian post (tuat) about 16 feet long is put in the ground near the plants leaving some 12 feet above ground for the vines to grow around Burnt earth is applied to the growing vine 3 times a year until it bears, which is about 2 years after planting; while the vine is maturing the flowers appearing on the growing shoots are plucked.

After two years' growth, when the vine is considered mature, flowers are left to seed but the young shoots are thinned out continually; the stronger shoots are tied to the post by means of a jungle twine made from "kulit sla-ut," at this period the vines are manured with pawn refuse (abok sessar), about 6 tahils being applied to each vine.

The crop is harvested about 10 months after flowering, in the months of July to September. If the crop is weak quantities of berries drop to the ground; these are gathered up to be marketed as black pepper.

This is the more usual method of cultivating pepper at the present time; in the old days, however, the method of cultivation took longer, the method being as follows:—

When the shoots from the young plants had reached a height of about 6 feet up the post they were pulled down and curled around the foot of the post, three or four of these shoots were layered, the rest being cut off; these layered shoots being again thinned out as the vine grew up the post until the vine was considered mature, about 3 years after planting, when the flowers were left to seed.

Although by this method the vine did not come into bearing until 3 years after planting, it continued to bear heavier crops for some 20 years, as against 10 to 15 years by the present method

To continue the description of the growth and care of the pepper vine: when vines approach the bearing season they are sprayed with a mixture of rotten tobacco and tuba, prepared with water; but even this spraying does not appear to prevent the spread of the fatal disease of black berries known amongst Chinese as "Voo Choon."

It is this disease which has done such damage to the gardens of Upper Sarawak district that the industry is dying out

PREPARATION

White Pepper is produced from the plucked berries which are gathered during the harvest, packed in gunny bags and immersed in water for about one week or until the outer skin of the berries has rotted off

After immersion the berries are put into baskets and washed, during the process the baskets are rotated by hand, when the rotted outer skin rubs off and is easily separated from the clean berries remaining

The washed seeds are then sun dried, after which they are shaken up in large open baskets, the stalks being separated from the seeds during this winnowing process

The dried seeds are now ready for the market; only 5% moisture is allowed to be contained in the finished product; this standard is maintained by Government regulations and Inspectors are appointed to control this.

Black Pepper.—There are three methods of preparing black pepper

(1) The plucked berries are piled in heaps in the house of the planter where they are left for three days, after which they are sun dried for another three days.

(2) The plucked berries are poured into boiling water after which they are sun dried.

(3) The berries are smoked over a fire, being placed on mats made of small sticks and twigs until dry.

*Extracted from "Notes on Sarawak Trade," published by the Committee for Agricultural and Forest Exhibits, Malaya-Borneo Exhibition.

We have already noted that the dropped berries as well as those plucked are prepared for Black Pepper.

FINANCIAL ARRANGEMENTS.

In Sarawak, gardens are generally owned by the individual planter, who mortgages the crop to a merchant in return for provisions during the unproductive period; after the first crop is gathered the whole of which is delivered to the mortgagee and settlement of his account has been made, he applies for an advance on the forthcoming crop; this is usually given partly in cash and partly in provisions.

The merchant sends his agent to examine the applicant's garden who estimates the quantity of the forthcoming crop and reports to the merchant who allows the planter up to 60% of the estimated value of the crop

This system continues and advances are given against the forthcoming crop annually.

The pepper gardens in Upper Sarawak are rapidly dying out, but it is being planted in the 2nd and 3rd Divisions of Sarawak. The crops from these newly planted districts are superior in quality to those produced in the older districts—this fact is probably due to the washing of berries in the clear running streams instead of in ponds which was the more common method in Upper Sarawak.

Pepper is also produced in Lundu and Simatan, but at the former place the gardens are dying out owing to the ravages of black berry disease.

It is said that the newly planted area in the 2nd Division has already been attacked by this disease.

Unless something is done to stop the spread of Voo Choon it would appear that the pepper industry of Sarawak is doomed.

BAZAAR GOODS FOR THE RED SEA DISTRICT.

The greater part of the 15,000,000 people, who occupy the 850,000 square miles of territory which make up the Red Sea district, live a very primitive existence. Their demands are not elaborate and are supplied almost entirely by petty traders and itinerant merchants. There are certain elementary articles which are required and which these merchants supply. At present these articles are bought in small lots separately, packed into boxes or bales suited for transport on camels, and thus hawked around the country. In the larger towns the same goods are retailed from small stalls. Aden merchants, writes the United States Consul at Aden, have conceived the idea of purchasing from Europe, America, or elsewhere, boxes already made up of assorted articles of the types finding a sale among the inhabitants.

Among the articles which find a sale at Aden may be mentioned laundry soap, sewing needles, thread, twine, writing paper, pencils, penholders pens, ink in powder form, ink pots, small slates for use in the schools, blank books, pocket notebooks, penknives, scissors, purses, mirrors, handkerchiefs, socks and toys.

Before the war Germany and Austria supplied the bulk of these articles, and since the war the Japanese have largely secured the market. In all these cases, however, the sales have always been to concerns which resold the articles in small lots to the traders. Boxes already made up would, in the Consul's opinion, appeal strongly to the traders.

The dealers are all men of limited capital, and as a rule 45 to 60 days' credit is desired. In some cases, however, 25 per cent. would be paid in advance. Quotations in sterling are preferred by local merchants. For transportation on camel back the boxes should not weigh over 250 pounds each, which would permit two to be loaded on the animal.

The primary consideration on the local market in any case is cheapness. The Japanese goods are, for the time being, dominant by virtue of this advantage, but their inferiority of quality is very much disliked. Connections established in Aden would open a steady market and would penetrate the entire district.

COCA PRODUCTION IN JAVA.

The cultivation of coca was introduced in Java in 1880. There are now, principally in East Java, 63 estates comprising 6,000 acres planted in coca, according to official statistics. On practically all of these estates, writes the United States Consul at Soerabaya, coca is planted with coffee, rubber, and cacao, as a subsidiary crop. The plants are grown from seed and transplanted when they are six inches high; the first leaves may be gathered after a growth of eight months. Mature shrubs will yield from 700 to 850 pounds of leaves per acre. The bulk of Java coca is shipped to the Amsterdam market, the United States and Japan being the other principal purchasers. The exports of Java coca for the years 1916 to 1920, with the quantity shipped to the United States and Japan, were as follows :—

Year.	Total Exports.	Exports to United States.	Exports to Japan.
	Pounds.	*Pounds.*	*Pounds.*
1916 ...	897,600	600,600	4,400
1917 ...	598,000	517,000	37,400
1918 ...	1,456,400	897,600	558,800
1919 ...	2,186,000	275,000	235,400
1920 ...	3,755,400	24,000	649,000

Java coca has about the same alkaloid content as the Peruvian product. The basic alkaloid or Peruvian coca, however, is cocaine, while that of Java coca is cinnamylcocaine.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

REPORT ON THE "OWEN JONES" AND "MULREADY" PRIZES COMPETITION.

With the kind assistance of the Director of the Victoria and Albert Museum, the Council again arranged for a competition of students of Schools of Art in accordance with the terms of the Owen Jones Trust. Notices were issued in October last stating that six prizes would be offered under the usual conditions, each prize consisting of the Society's Bronze Medal, and a copy of a book or books on Applied Art, of a value not exceeding £2, to be selected by the successful competitors. In addition to these a Special "Mulready" Prize of £20 was offered for the best design (irrespective of class) submitted. The subjects of the competition this year were:—

ARCHITECTURAL DECORATION: Including Stained Glass, Mosaic for Walls and Floors, Plasterwork in relief and incised, Inlaid Marble and Stones, Lettering for Memorials.

WOODWORK AND CABINET WORK: Including Carving in Wood, Ivory and Bone, Inlay, Chairs, Chests, Cabinets.

TEXTILES*: Including Tapestries, Carpets and Rugs, Moquettes, Floor-coverings (*e.g.*, Linoleums and Floor-cloths).

The date for the receipt of competing designs was fixed for June 17th, 1922, and arrangements were made for their inspection at the Victoria and Albert Museum.

The following judges were appointed by the Council to consider the designs submitted:—Mr. J. H. Dearle, Mr. A. F. Kendrick (Department of Textiles, Victoria and Albert Museum), Mr. Eric Maclagan (Department of Architecture, Victoria and Albert Museum), Lieut.-Colonel E. F. Strange, C.B.E. (Department of Woodwork, Victoria and Albert Museum), and Sir Frank Warner, K.B.E. Sir Charles Allom, Mr. Robert Anning Bell, A.R.A., and Professor Selwyn Image were also appointed, but were unable to attend.

The competition was in former years conducted by the Board of Education in connexion with the National Competition, but since 1917 it has been conducted by the Royal Society of Arts. The figures for the six years are as follows:—

Year.		No. of designs.	No. of competitors.	No. of Schools presenting candidates.
1917	..	120	73	22
1918	..	37	31	9
1919	..	50	31	9
1920	..	94	63	17
1921	..	237	181	36
1922	..	134	118	29

The centres represented were [the figures in brackets show the number of competitors in each case]:—Belfast (1); Blackburn (2); Bury (2); Bury St. Edmunds (2); Cheltenham (1); Coalbrookdale (2); Darlington (3); Dewsbury (13); Glossop (1); Guildford (1); High Wycombe (3); Leeds (8); Leyton (4); Liverpool (12). London: Battersea (1); Brixton (1); Hammersmith (5); Hornsey (5); Putney (4); Macclesfield (13); Manchester (2); Morecambe (1); Norwich (1); Nottingham (5); Portsmouth (2); Stockport (1); Sunderland (5); Watford (13); West Bromwich (4).

The designs submitted were divided as follows:—Architecture:—Decoration, 7; Memorial Tablets and Lettering, 18; Stained Glass, 12; Mosaics, 16.

Woodwork and Cabinet Work, 16.

Textiles:—Woven Fabrics, Tapestries and Carpets, 37.

* It should be noted that only the classes of Textiles mentioned above were eligible in 1922.

Floor Coverings, Linoleums and Floor Cloth, 22.

Printed Materials, Cretonnes and Wall Paper, 6.

The Judges regret that there was a considerable falling off in the number of designs submitted, as compared with 1921, although there is a marked increase, as compared with 1919, when the subjects of competition were the same as this year. Unfortunately the advance in the general standard of excellence, to which attention was drawn in last year's report, was not maintained. In the Tapestries, for instance, there was a great want of originality; the designs for linoleums were exceedingly commonplace, and the lettering, even though of better quality, was not free from faults. The Judges, therefore, recommend the award of only five of the six prizes offered, and the special "Mulready" Prize of £20. The awards are as follows:—

ARCHITECTURE.

Prize.

Rex W. Woods, School of Art, Norwich (Marble Memorial Tablet).

Commended.

James E. Connor, Ryland Memorial School of Art, West Bromwich (Design for a Memorial Tablet in Cast Green Bronze, ¼ scale, with full-size detail).

Lot Ramsden, School of Art, Leeds (Lettering in Marble).

MOSAIC.

Medal and Special Mulready Prize of £20.

Miss C. Honor A. Howard-Mercer, L.C.C. School of Arts and Crafts, Hammersmith (Design for Mosaic with full size detail).

Commended.

Catherine M. Pargeter, School of Art, Watford (Design for Mosaic Floor).

WOODWORK AND CABINET WORK.

Prize.

Henry W. Keil, School of Art, Guildford (Looking Glass and Stand—Design and Work).

Commended.

Arthur Clegg, School of Art, Cavendish Street, Manchester (Carved Cabinet).

TEXTILES.

Prize.

F. Smith, Municipal Technical College, Blackburn (Woven Tapestry Work)

Commended.

John Burgess, School of Art, Macclesfield (Design and Draft for Woven Tapestry Panel; Woven Panel from above Design).

Fred Wright, School of Art, Macclesfield (Design for a Woven Tapestry Hanging).

Hilda Morfett, School of Art, Sunderland (Design for Tapestry).

CARPETS.

Prize.

Walter J. Bartrum, L.C.C. School of Art, Oxford Road, Putney, S.W. (Design for Wilton Carpet and Border for same).

Commended.

George Kershaw, School of Art, Macclesfield (Design for a Hand-Woven Carpet, Detail of Border, full size).

LINOLEUM.

Commended.

Ivan Stanway, School of Art, Macclesfield (Design for a Printed Linoleum).

Arrangements have been made for the exhibition to the public of the competing designs as in previous years. They will be on view from July 29th until September 17th, from 10 a.m. to 5 p.m. (on Sundays from 2.30 to 6 p.m.) in Room 132, Department of Textiles, Victoria and Albert Museum, South Kensington, S.W.

In announcing the awards, the Council desire to express their thanks to the Judges for the trouble they have devoted to the work, and for the promptitude with which the awards have been made.

They wish also to state their appreciation of the assistance rendered to the Society by the Director of the Victoria and Albert Museum and his staff.

The full conditions and arrangements for the Competition in 1923 will be announced later.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

INKS.

By C. Ainsworth Mitchell, M.A., F.I.C.

Lecture I.—*Delivered January 23rd*, 1922.

It is 65 years since a communication was made to this Society on the subject of Inks, and as much knowledge has been gained since then, I venture to think that some record of the various investigations that have been made may be of general as well as specific interest.

In the paper read by Mr. Underwood in 1857 (*J. Soc. Arts*, 1857, p. 67), a brief outline was given of the history and processes of manufacture of writing, printing and copying inks, and certain criticisms were made and conclusions were drawn, to some of which I shall refer in the appropriate places.

Referring to the earliest type of writing inks, Mr. Underwood pointed out that their basis was carbon derived from lamp-black or some fine form of charcoal. There appears to be no doubt on this point, for we have no evidence as to the use of any other type of ink from the two oldest sources—China and ancient Egypt.

Fortunately in the case of China, a wonderful old manuscript by Chien-ki-Souen, dating back to about B.C. 2697, was unearthed. This was translated into French and published with its original illustrations by M. Jametel in 1892. The entire process of making Chinese ink, from the preparation of lamp-black to the moulding of the mixture of glue and black, is shown in these illustrations, some few of which are shown upon the screen. I think it will be generally admitted that, apart from their technical interest, these remarkable drawings, like much of the Chinese work, are most beautiful in design, full of vitality, excellent in composition and skilfully drawn.

The method of preparing lamp-black shown in the first diagram is essentially the same as has been used for thousands of years; that is to say, oil or other vegetable material is burned with a limited supply of air and the smoke collected in cold receivers, in this case made of terra-cotta. Much skill is required to stop the process at the right moment, to prevent the lamp-black becoming yellow. In order to have the lamp-black in a fine state of division it is sifted into china vessels and dried and subsequently mixed and heated with a strained solution of glue and then pounded for hours. The resulting mass is made into sticks, which are afterwards moulded into cakes and dried in the ash from rice straw.

A rational development in the process is that mentioned by Julian (Ann. de Chim., 1833, 53, 308), who, quoting from early Chinese documents, describes how the black was fractionated into finer and coarser qualities by conducting the smoke through a series of connected chambers made of bamboo covered with paper, the finest grade being deposited in the chamber furthest from the lamp. The principle of this method has also been used in modern methods of making lamp-black.

The rate of subsidence of the carbon affords a rapid means of testing the quality of Chinese or Indian ink. In applying the test, equal weights of the preparation are ground up with equal volumes of hot water, and the amounts of residue measured after similar periods of time. In this way it can be readily demonstrated that the best grades of Indian ink are composed of finer lamp-black than the commoner grades.

In general, Chinese ink, in sticks, contains about 8 to 9 per cent. of water, 52 to 54 per cent. of carbonaceous residue and 5 to 7 per cent. of nitrogen (derived from the glue), and yields about 3.5 per cent. of ash. Typical analyses will be found in my book on Inks (p. 29).

If we turn to ancient Egypt, we have not, so far as I am aware, any description of the methods of preparing inks, similar to the Chinese MSS., but we have actual specimens of the slabs and mullers used for grinding the ink, specimens of the early ink itself and innumerable examples of the ink in papyri and parchment documents. It seems probable that carbon ink was prepared in solid sticks as in China, although judging by the fact that fine reed pens were used on some of the papyri about the 7th century B.C. the ink must also have been used in a more fluid form. This is confirmed by the discovery of inkstands still containing some of the dried ink. Mr. A. Lucas, Director of the Government Laboratory in Cairo, has a paper in the current volume of "The Analyst" p. 9, on the subject, in which he gives an account of his examination of the remains of ink from an inkstand of the 16th Century B.C., and proves that the

basis of this is carbon. In fact, all the ancient Egyptian inks appear to have been carbonaceous in character, for such ink is present on potsherds, and on papyrus as late as the 5th Century B.C. I am indebted to Mr. Lucas for his kindness in giving me the opportunity of examining, not only such early specimens as these, but also in taking the trouble to send me various old Egyptian books and manuscripts and allowing me to show them here this evening. I have repeated much of his work on these actual specimens and am therefore in a position to confirm his results.

In Mr. Underwood's paper before this Society, the opinion was put forward that the inks in certain early writings alleged to have been carbon were probably mixtures of a carbon ink and an iron ink, since some were brown and others yellow in tint, and in his opinion this was hardly possible in the case of a pure carbon ink, since carbon was supposed to be quite unalterable. This question is among those dealt with by Mr. Lucas, who shows, first of all, that the writing on some old papyri is brown in colour and yet consists of carbon without any iron. This also applies to the ink on many later MSS., and it is significant that the change from what was, presumably, black to brown has in some cases only affected certain characters on a page. The probable explanation of this change from black to brown is that it is due to the impurities in the carbon, which in the case of inferior qualities was obtained from such materials as carbonised date-stones. Traces of tarry oils, and iron compounds would thus be introduced into the ink, and it is more reasonable to infer that the slight reaction for iron given by some old carbon inks is due to this cause, rather than to a deliberate mixing of two kinds of ink as suggested by Mr. Underwood. For example, in the old Arabic account book of 1181 A.H. (A.D. 1767) the ink gives a faint reaction for iron, but not sufficient to indicate the presence of an iron ink. The brown colour of some of the ink is also to be attributed to a fine coating of a glittering substance, possibly mica, used for drying the ink.

Carbon inks are still in use at the present day in Egypt. Mr. Lucas gives analyses of typical commercial samples, and it is interesting to note that in the case of the best quality of ink the rate of subsidence of the carbon is very slow. For example, best black writing ink, Tabrizy, contained originally 16.1 grams of total solids per 100 c.c., whilst, after 8 years, the liquid above the deposit still contained 15.2 grams per 100 c.c. In the case of a poorer quality, however, the total solids had fallen in the same period from 12.0 to 6.2 grams per 100 c.c., and these contained no carbon, the whole of it having fallen to the bottom of the bottle. Both of these inks gave slight reactions for iron, obviously due to impurities in the ingredients.

The earliest known instance of the occurrence of an iron ink is in a parchment examined by Mr. Lucas dating back to the 7th or 8th Century A.D., which is a century or so earlier than has previously been recorded.

An interesting instance of the use of both a carbon ink and an iron ink in the same MSS. is to be seen in a portion of the Old Testament written in Arabic and bearing the Coptic date 1028 (A.D. 1312). The ink in most parts of the book is brown and has an iron basis, whilst in some pages the ink is black and is carbonaceous. The carbon ink gives slight reactions for iron, but there is no justification for concluding that carbon and iron inks have been purposely mixed.

From Egypt the use of inks spread into Europe, and the old Greek and Roman papyri frequently show very black writing, which is invariably due to carbon ink. An interesting historical example of Roman papyri was afforded by the fragments which were found in the ruins of Herculaneum and were examined by Sir Humphry Davy. No trace of any iron ink was found, and it would appear that the use of iron-gall ink was unknown to the Romans of that date, since it is not mentioned by Pliny. Carbon ink does not adhere readily to the surface of parchment, and it is not improbable that the adoption of that material as the medium to receive the writing had much to do with the replacement of carbon inks by iron-gall inks. The earliest reference to be found to the use of the latter is in a Cyclopædia of Christian Art written by a monk named Theophilus in the 11th Century, but the evidence that Mr. Lucas has been able to bring forward shows that iron inks were known three of four centuries before that date. In the 12th and 13th Centuries there are several references to iron inks, but it seems probable that the use of carbon ink was continued for a long period after the general adoption of iron inks.

Another ink, the basis of which is not carbon, but a carbonaceous pigment, is sepia, which is obtained from the ink sac of the common cuttle fish, *Sepia officinalis*. This has long been known as a natural ink, for allusions to its use are made by Cicero, and, later, by Persius (A.D. 34-62).

In preparing sepia, the ink sacs are dried and powdered, and boiled for some time with strong alkali. This extracts the pigment and, on then neutralising the extract with acid, the sepia is precipitated as a fine powder and is washed, dried and ground up and made into cakes or oil paints.

The pigment itself is a highly complex compound of a protein character. A specimen which I prepared and examined contained 8.4 per cent. of nitrogen and yielded 12.22 per cent. of ash. Different compounds to which names such as "melanin" and "sepiaic acid" have been given, have been isolated, but it is questionable whether these can be regarded as definite individuals.

Sepia is sometimes adulterated with brownish carbon, but the latter may be distinguished by the fact that it cannot be bleached by hypochlorites, and that it does not contain any appreciable amount of nitrogen.

The permanency of various pigments was investigated by Dr. Russell and Sir William Abney, and their results were communicated to this Society (*Journ. Soc. Arts*, 1889, 37, 113). Referring to sepia they pointed out that it was a popular mistake to regard that pigment as permanent since it was decidedly fugitive, as was shown by the fading of sepia drawings of the early 19th Century.

Iron gall inks are known to have been used in this country as early as the 9th Century A.D., for it was proved by Sir Charles Blagden (Trans. Roy. Soc., 1787, 77, 451) that the writing on various vellum MSS. of that date and later, contained iron but no carbon. To quote his words: "No trace of a black pigment of any sort was discovered."

There are numerous early references to the methods of making iron-tannin inks. In the treatise of Theophilus of the 11th Century, to which allusion has been made, an extract of thorn wood is mentioned as the source of the tannin. This was evaporated to dryness and the resulting powder mixed with green vitriol (ferrous sulphate).

Another early reference is to be found in a treatise on metals (*De Rebus Metallicis*) which was written in the 11th Century by Albertus Magnus, and from that time onwards the preparation of iron gall inks is described by most of the early writers on natural objects.

An entire book on the subject of inks was written in Latin by Canneparius, Professor of Medicine at Venice, and an edition of this was published in 1660 in London. Referring to iron gall inks he quotes an Italian rhyme to the effect that the best ink was made by mixing one part of gum, two parts of green vitriol and three parts of galls in thirty parts of water.

At one time the preparation of ink was as much a part of the duty of the house-wife as the brewing of beer and making of bread, and the recipes for its manufacture were handed down within each family.

A number of such old household books are still extant, and that belonging to the Fairfax family was published in *facsimile* some years ago. Among the many recipes are several for making ink, the earliest of which, judging by the handwriting, is of the Elizabethan period. The preparation of ingredients in the different formulæ show wide variations. In two of them one ounce of copperas (ferrous sulphate) is used to two ounces of galls, whilst in a third the quantities are 4 of galls to 3 of copperas.

A curious book on writing, written by John de Beau Chesne and M. John Baildon, and printed at Blackfriars in 1571, contains directions in rhyme for making ink, in which the proportions given are 5 of galls to 3 of copperas.

It will thus be seen that these different formulæ must have produced inks of varying types.

In the 18th and the early part of the 19th Centuries the proportion of the two main ingredients was studied scientifically and similar discordant conclusions were drawn. For example, Lewis (1760) recommended the use of 3 parts of galls to one of copperas; Eisler (1770), 4 parts of galls to 2 of copperas; Ribeaucourt (1792), 2 parts to 1; Reid (1827), 1 of galls to 3 1/7 part of ferrous sulphate.

I have shown elsewhere ("Inks," Chas. Griffin and Co.) that these variations must be attributed to the fact that different kinds of galls contain different proportions of tannin, which is the active agent that

combines with the copperas. Hence it is essential that a formulæ should be based on the analysis of the particular galls in question. For example, it is quite practicable to make ink from the common galls found on English oaks, but these contain relatively so little tannin that three times as much would have to be used as of good Chinese galls, and more than twice the quantity required in the case of Aleppo galls.

Whatever the method of preparation used for these early inks the product was of a different type from the writing inks of the present day. The process then involved exposure of the ink for a considerable time to the air, so that the darkening process, due to the formation of a colloidal iron tannate, took place within the ink itself. The object of this practice was that the ink might not be too pale when first applied to the paper, but it had the drawback that the oxidation not infrequently proceeded too far and deposits were formed in the ink-pot.

In the modern type of ink the solution of iron tannate is kept, as far as possible, in an unoxidised condition and when applied to the paper at first produces only a faint buff coloration, which slowly darkens as it becomes oxidised, reaching its maximum intensity of colour in a period of days, weeks or months, according to the conditions. In order to give colour to the writing pending the formation of the true ink pigment, small proportions of indigo or aniline colours are added and the product is usually termed "blue-black ink," "violet-black ink," or the like.

The first reference to the use of indigo for colouring ink is that made by Eisler in 1770, and its use was introduced into this country by the firm of Stephens in 1836. It was first patented in Germany in 1856, by the firm of Leonhardi of Dresden, who claimed the use of both indigo and madder for the purpose and described his products as "alizarine inks." Subsequently, the madder was omitted, but the term "alizarine" was still retained.

If the inks prepared from ordinary gall extracts and tannic acid are to remain stable in the bottle, it is necessary to add a certain proportion of a free acid, which is usually sulphuric, hydrochloric or oxalic acid. This also has the advantage of causing the ink to penetrate the paper more readily, but, on the other hand, has the drawback of corroding steel pens.

In the attempt to produce an ink which would not have any corrosive action upon steel pens, various methods have been tried, but the most successful have been those based on the use of gallic acid. This acid is formed by exposing gallo-tannic acid derived from galls to a fermentation process, which is brought about by the action of certain mould fungi. It differs from gallo-tannic acid in being much less soluble in water (1 part in 130 parts at 12.5° C.) and in not combining with gelatin to form an insoluble compound. The compounds which it forms with iron, however, are much more stable in solution that the tannates of iron, and whereas the latter require the presence of acid to keep the ink stable, neutral solutions of iron gallate will remain unchanged for a long time and throw down but little deposit even when exposed to the air.

As against these advantages of stability and neutrality, gallic acid inks are generally regarded by ink-makers as being deficient in power of penetrating the paper, and they undoubtedly contain too little iron for a standard ink.

In some published formulæ, gallic acid inks are made by oxidising an extract of galls prior to the addition of the ferrous sulphate: this was first suggested by Reid in 1827. Such inks will usually consist essentially of a mixture of iron tannate and gallate, and will have some of the advantages of each.

With the exception of the introduction of gallic acid inks and of unoxidised inks of the "blue-black" type, the process of ink-making to-day is essentially the same as it was five hundred years ago.

Galls are crushed and extracted with water, and the extract treated with a solution of copperas (ferrous sulphate) in the proportion which has been found to give the best results in practice, with the particular galls employed. It is essential to economical working that a colorimetric estimation of all the tannin compounds in the galls should be made, since the preparation of gallotannic acid in Chinese or Japanese galls is much higher than in Aleppo galls, and different quantities of the iron salt will therefore be required.

After admixture of the main ingredients, the crude ink is allowed to stand in order to mature, and in this process throws down a heavy sludge, the amount and character of which will vary with the nature of the galls. The subsequent stability of the ink will

depend largely upon sufficient time having been allowed for this maturing process to be complete. The quantities of gum and provisional colouring matter to be used are, within certain limits, a matter of choice, but the amount of acid used to ensure stability must be kept at the point that is just sufficient for the purpose. If too much acid is used the ink will certainly be excessively corrosive, and may, under certain conditions, be decomposed.

In the preparation of gallic acid inks, which should be free from strong acid, it is necessary to choose a sample of copperas with as little free acid present as possible. In a discussion on a paper which I read before the Society of Public Analysts on this subject (*Analyst*, 1921, 46), Mr. Rudd Thompson suggested that ferrous ammonium sulphate might with advantage be substituted for ordinary ferrous sulphate in gallic acid inks, since it could readily be prepared without any free acid, and preliminary experiments which have been made have shown that the suggestion is worthy of the attention of ink manufacturers.

An interesting series of iron gallates has been prepared by Silbermann and Ozovitz (*Zeitsch. angew. Chem.* 1907, 2065), starting from a mixture of gallic acid and ferric chloride. This yields a chloro-ferri-gallic acid, which on treatment with ammonia is converted into a salt, ammonium oxy-ferri-gallate. When dissolved in water, this yields a solution which can be used as an ink. It gives violet-black characters which darken rapidly and after exposure to the air for about an hour cannot be removed by treatment with water.

Finally, I may refer to a new double iron salt which has recently been discovered and patented by Dr. Röhm. This is a ferric sulphate-chloride with the formula $Fe\ SO_4\ Cl.\ 6H_2O$. It is remarkably stable and is not hygroscopic or deliquescent. The great advantages claimed for its use in the making of ink are that it does not, like ordinary ferric salts, act upon aniline dyes, changing their colour, and that, unlike ferrous salts, it does not throw down a deposit when oxalic acid is used as the acid to render the ink stable.

LECTURE II.—*Delivered January 30th*, 1922.

The writing inks so far described may all be classified under the general term of "iron-gall inks," since, although different raw materials are used in their manufacture, the active ingredient in each case is a tannic acid or one of its derivatives.

Of the numerous substances forming coloured compounds with iron salts, the tannic acids have been found by long experience to be the most generally suitable from all points of view for the purpose. There are, however, numerous other organic compounds which combine with metallic salts to form coloured derivatives which have a sufficient degree of permanency on paper to be termed inks; and, again, there are other metallic salts, besides those of iron, which will combine with tannin to form inks.

The property apparently depends upon the chemical constitution of the organic substance. Thus it was shown by Schiff (*Ann. Chem. Pharm.*, 1871, 159, 164) that when a substance gives a coloration with ferric salts, the presence of a hydroxyl group is indicated, whilst Schluttig and Neumann established the rule that in order to obtain an ink, as distinct from a fugitive coloration, the substance must contain three adjacent hydroxyl groups.

I have shown (*Analyst*, 1903, 28, 146) that this rule of colour grouping also extends to inks containing ammonium vanadate and similar compounds. I have also found (*Analyst*, 1920, 41, 126) that osmium tetroxide (the osmic acid of the microscopists) follows the same rule, and the ordinary one per cent. solution combines with gallotannic and gallic acids to form an ink, whilst with pyrogallic acid it yields a splendid black which attains its maximum intensity almost immediately after application to the paper. If it were not that osmium compounds are too expensive for the purpose an osmium pyrogallate ink would be a valuable addition to the inks now in general use.

The inks which, after iron gall inks, are the best known, are those made from logwood, which was first introduced into this country as a dye about the time of Queen Elizabeth.

The use of a decoction of logwood to improve the colour of iron-gall inks was known in the 17th Century and was studied by Lewis in 1763. In early inks it would, therefore, play the part of indigo in affording provisional colour.

The inks which logwood gives with iron salts form a green coloured stain which gradually darkens on exposure. By using

alum as the metal salt a violet-black ink is obtained, whilst potassium chromate gives a black ink which is extensively used in Germany as a cheap school ink, and to a less extent in this country.

The drawback of neutral chrome logwood inks is that they are liable to gelatinise in the bottle, and it is, therefore, necessary as in the case of iron tannic inks to have a certain proportion of acid in the preparation to give stability. An ink upon these lines prepared from logwood ink and bichromates has recently been described by Walther (*Chem. Zeit.*, 1921), in which the violet tint of the ink can be modified either in the direction of red or blue by regulating the amount of acid.

Ammonium vanadate behaves in a similar way to iron salts with gallotannic acid, and has, therefore, been used, either by itself, or as an addition to iron-gall inks, in various preparations. Unfortunately, although the ink gives a good black stain on paper, the writing is by no means permanent, and gradually turns yellow, even when protected from the light. So far, I have not discovered any method of preventing this, and it would, therefore, seem that the advantage of using such an expensive substance is questionable.

The discovery of aniline dyes added a new source of ink to those previously available. The first patent taken out in England for the use of these dyes as inks was by Croc in 1861, and in 1867 a solution of nigrosine was put upon the market under the name of "stylographic ink," since its fluidity renders it suitable for fountain pens.

Coloured aniline dyes have also to a large extent replaced the old natural dyes, such as cochineal and Brazil wood for red, indigo for blue, and Persian berries for yellow.

At the present day, the dye known as eosin, which was discovered in 1874, is widely used for red ink and "soluble blue" for blue ink, whilst there are numerous green, violet and yellow dyes available.

The great drawback of all ordinary aniline writing inks is their instability, and it has been shown by Cross and Bevan (*J. Soc. Arts*, 1891, 39, 152) that eosin and methylene blue are particularly fugitive.

In examining writing inks it is necessary in the first place to take into consideration the purpose for which the ink is primarily intended. For instance, the requirements for an ink for record purposes will differ materially from those for a fountain pen ink. In the case of the former, permanence of the writing is the main consideration, and this can only be assured by introducing so much iron tannate or gallate into the preparation as to render it too thick for constant use in a fountain pen.

Many years ago the German Government laid down specifications for the composition of a standard ink, and their example has, within the last year or two, been followed by the British Government. In the specifications now issued to ink makers, it is laid down *inter alia* that an iron-gall ink for record purposes must contain not less than 0.5 per cent. of iron, and inks for fountain pens not less than 0.2 per cent. The lower limit must be regarded as the minimum in an ink the writing done with which may be accepted as reasonably stable. Hence, an estimation of the amount of iron in the ink is essential, and the maker's formulæ must be correspondingly modified in accordance with the analysis.

The degree of fluidity may be ascertained by estimating the amount of total solids in the ink. From 3 to 3.5 per cent. is a suitable proportion for fountain pen inks, whereas in the case of record inks, the proportion is frequently as high as 8 or 9 per cent. A simple and rapid method of controlling the degree of fluidity is to determine the efflux viscosity under standard conditions. The specific gravity is also a useful factor. For example, fountain pen inks usually have a specific gravity of about 1.015 to 1.020, whereas a record ink may give a result of upwards of 1.050.

The second essential for a good ink is that it should darken rapidly when exposed to the air on paper. This is conveniently tested by the method of Schluttig and Neumann, in which stripes of the ink are made upon standard paper fixed in a frame at an angle of 45°, the same quantity of ink being allowed to run from a pipette down the paper. The breadth and form of the stripes produced afford a preliminary indication of the character of the ink. When the ink is dry, the paper is left for eight days exposed to light and air and then compared with standard stripes made from a standard ink of specified composition. The paper is also cut into horizontal strips and different pieces immersed for some days in water, in 85 per cent. alcohol and in 50 per cent. alcohol, and the effects compared with those given by the stripes of standard ink.

The next essential of a good ink is that it shall be stable in the bottle and to a less extent in the ink-pot, and shall not change colour or form deposits prior to use. I have already mentioned that the final stability of the ink, in the case of gallotannic acid inks, depends upon the addition of the right proportion of strong acid and upon sufficient time having been given for the ink to mature in the factory. If too little acid has been added the ink will throw down a deposit; if too much, the writing will darken too slowly on paper and the pigments in the ink may even be bleached in the bottle, whilst steel pens are attacked to too great an extent.

The total acidity due to strong and weak acids in the ink may be rapidly determined after bleaching the ink with a measured quantity of hydrogen peroxide, whilst strong acids may be estimated by distilling the ink with sodium acetate and titrating the liberated acetic acid in the distillate.

In this connexion it should be mentioned that the bottles themselves should be tested for free alkali. During the past two years ink makers have had considerable trouble and numerous complaints from this cause. The ink would change its colour to dirty brown in the bottle and eventually throw down deposits or even become semi-solid. I have investigated numerous cases of this kind and have found the trouble to be solely due to the free alkali in the glass which gradually neutralised the free acid in the ink, with the result that the product became unstable and changed in this way. Gallic acid inks free from added mineral acid are also liable to be affected in this way and will change their colour and decompose if left in contact with alkaline glass.

It is remarkable that this factor should have been overlooked by ink manufacturers until I called attention to it last year (*Analyst*, 1921, 46).

The examination of ink in writing has frequently been found to afford conclusive evidence in criminal investigation. Under favourable circumstances it is possible to differentiate between two different makes of ink, or even between inks made by the same manufacturer at different periods. The theory underlying the method is that the two pigments, *i.e.*, the black iron tannate and the provisional dye, behave differently with various reagents and that the colorations produced will also vary according to the relative proportions of the pigments. The tannins derived from different sources will also contribute their share towards the reactions, as has been shown by Schluttig.

Since the war there has been a less pronounced difference in the behaviour of different inks since there has been much less variety in the blue dyes available for the manufacturer. In applying the tests Osborn's comparison microscope is invaluable, since it enables the inks on different documents to be brought into juxtaposition within one field, this effect being obtained by means of prisms reflecting the two images into one eye piece.

This microscope has also been adapted for recording the colour either of the original ink or of the colorations produced by the various reactions. A description of the most suitable tests will be found in a paper which I read before the Society of Public Analysts (*Analyst*, 1908, 33, 80). These reagents include bleaching agents, oxidising agents and reducing agents, and reagents giving colorations with iron salts. The first occasion on which these methods were applied in an English Court of Justice was at the trial of the poisoner Brinkley, when it was proved that there were three distinct inks upon a forged will.

The question of determining the age of an ink in writing is a much more difficult problem, and it is only when the conditions are very favourable that a decided opinion can be expressed upon the point. There is, of course, a decided difference in the appearance of very old and of modern ink, apart from the fact that the edges of the lines in modern writing frequently show indications of the two points of a pen nib. In very old ink the surface of the pigment is broken up and irregular in its intensity, whereas in modern ink the colour is brighter and there is a sort of crystalline appearance, due mainly to the pigment attached to separate fibres of the paper.

The presence of a bright blue dye is also a distinguishing feature in many modern inks, and can be readily detected by the use of acid reagents which bleach the iron tannate, leaving the blue dye. Aniline dyes were unquestionably used in inks more than forty years ago, but their presence in the inks in entries in old family Bibles put forward as proofs that claimants for old age pensions were 70 years of age has on several occasions been fatal to the claim.

Evidence of a similar character was given at the trial of *Rex* v. *Menzies* in 1916, on the charge of uttering forged documents, alleged to date from 1719 to 1792, in support of his claim to a baronetcy. Aniline dyes were present in the inks which were, therefore, obviously not 18th Century inks.

In some cases inks have been artificially aged by the addition of Indian ink, but this can be readily detected by the use of a bleaching agent, which will decolorise the iron ink and leave the particles of carbon unaffected.

Occasionally, the colour of the ink affords some information as to its age. When a modern blue-black ink is freshly applied to the paper the change of colour from bright blue to what is apparently black takes place very rapidly at first, but the final change may not be complete for upwards of a year. Hence, if a record is taken of the colour of the ink in a given piece of writing and again after a few days, and it is found that a material change has taken place, there can be no doubt that the writing is comparatively recent.

Naturally, in such estimations, it is necessary to take into consideration whether the ink has been blotted, since the effect of blotting is to remove variable quantities of the two pigments present, and the final colour will also depend upon the lapse of time, in seconds, between the time when the ink was placed on the paper and the application of the blotting paper. The danger of losing sight of this factor is illustrated by the case of *Rex* v. *Cohen*, in which a charge of fabricating entries in a ledger was based on the fact that several of them were paler in colour than the adjacent entries. This was fully accounted for by differences in the times of blotting, and, apart from that, the sequence of the strokes of the writing, as compared with adjacent entries, showed that in the case of one of the disputed entries, at all events, the charge was not supported by the facts.

When two strokes made with ink at approximately the same time cross each other it is, as a rule, not possible to determine which stroke is uppermost; but, if one of the strokes is allowed to dry and a second then drawn across it, it is frequently possible to observe with the microscope that the more recent stroke passes above the other.

In this particular case parts of the lines in the entry following the disputed entry in the ledger could be seen to be uppermost, thus proving that this entry had been made in its proper sequence.

Sometimes it is possible to prove the relative age of an ink in writing by means of chemical tests, although only in the case of inks, such as iron-gall and logwood inks, which undergo chemical changes after being applied to the paper.

All the tests of this kind which have been published depend essentially upon the same factor, *viz.*, the changes in the chemical composition of the black pigment, the iron tannate, from a soluble into an insoluble form.

I have pointed out already how this change, which occurs by oxidation on exposure to the air, is indicated to the eye by a gradual darkening in colour, the black pigment formed blending with the original blue of the dye in the case of blue-black inks. But even when the maximum intensity of colour has been produced, the final stage at which the chemical compound in the ink on the paper becomes stable has not been reached, and a period of four or five years is required, under normal conditions, for its development.

From the results of a series of experiments, the details of which are recorded elsewhere (*Analyst*, 1920, 45), I have been able to give the probable explanation of these changes.

The ink in the liquid stage consists mainly of a soluble tannate. On exposure in a film to the air this slowly changes, firstly into a colloidal form, in which it will pass through coarse filter paper, and then into a tannate, which is insoluble in water, but will dissolve readily in dilute acids, and finally into a tannate which resists for a long time the action of dilute acids.

These several tannates appear to correspond with individual tannates which have been isolated.

The tannate insoluble in water which first forms is probably a compound, first prepared by Wittstein (*Jahresber. Chem.*, 1848, 28, 221), containing 5.53 per cent. of iron; and this, when exposed to the air, slowly changes into a tannate nearly insoluble in dilute acids; this contains about 8.0 per cent. of iron, corresponding with the requirement of a tannate prepared by Pelouze in 1833. Compounds containing proportions of iron between these extremes are probably mixtures of these two tannates.

At early stages, after being put upon the paper, the ink in writing probably consists mainly of a mixture of a soluble tannate and the tannate insoluble in water. One or more copies can, therefore, be taken from writing for some time, and upon this fact have been based tests for forming an estimate of the age of ink, such as were first proposed by Sittl in 1891, and by Habermann and Ossterreicher in 1901.

Any conclusions based on this method, however, are liable to be affected by the composition of the ink used, and it is only when the differences are very pronounced that any reliance can be placed on the results of copying tests. It may, however, under exceptional circumstances, be useful as a confirmation.

The difference in the behaviour of the earlier and later insoluble tannates is of more value. When writing, say, not more than one or two years old, is tested with a drop of dilute acid, such as 5 per cent. oxalic acid, it will react immediately and run over the paper; whereas an ink in writing of ten or more years of age will remain relatively unaffected for a long time. It is curious, too, that after the formation of the more insoluble tannate the blue dye also becomes protected from the action of the acid, and the ink in the writing does not smudge.

Before any conclusion can be drawn from the results of the test, it is essential that the chemical behaviour of each of the constituents in an ink should be known, that the differences should be very pronounced and that the dates of the writing should not be too close. In the case of *Rex* v. *Pilcher*, tried in 1910, all these conditions were present. The inks on an alleged will, stated to have been written twelve years previously, reacted immediately with different reagents, and the blue dye spread over the paper. Similar tests applied to documents of the alleged testatrix five or six years old showed no signs of diffusion, and there could be no doubt that the writing was not as old as was alleged.

Tests of this kind are obviously not applicable in the case of documents written with an aniline ink. Since such inks do not undergo oxidation to form a pigment, on exposure to the air, copies can be taken from them at any time until they have faded, and no difference will be observed in the behaviour of new and old writing.

The examination of ink on charred fragments of paper requires special precautions, as was pointed out by Sir Humphry Davy in his account of the Herculaneum papyri. Even when the paper has been burned to a black cindery leaf, writing done with an iron ink may still be rendered visible under favourable circumstances, since the iron oxide from the iron salt in the ink will remain on the paper. The most suitable method is that first suggested by Habermann, of coating the paper with a solution of aluminium acetate or other salts and then gently igniting it, so as to leave a white coherent ash, upon which the iron can then be rendered plainly visible by treatment with a reagent. The principle is the same as that used in the manufacture of gas mantles.

LECTURE III.—*Delivered February 6th,* 1922.

I have already explained the reason why any iron-gall or logwood ink is capable of yielding one or more copies for some time after it has dried upon the paper, viz., that there is present an iron tannate which is still soluble in water, and only changes gradually into an insoluble tannate.

In the preparation of ordinary commercial copying inks, advantage is taken of this property, and the solubility of the partly dry ink is intensified by greatly increasing the proportions of the normal ingredients, and, in addition, adding a small amount of a substance such as glycerin, sugar or dextrin syrup in sufficient quantity to make the writing only very slightly sticky immediately after writing, and to be free from stickiness after the copy has been taken.

An ink prepared in this way will obviously yield copies for a very much longer time after writing than an ordinary iron-gall ink. Owing to their containing a considerable proportion of substances other than tannin, myrobalans are sometimes used in preference to galls as the tannin material for copying inks.

The new iron salt, ferric sulphate chloride, described in my first lecture, also makes a good copying ink.

An analogous principle is used in the case of logwood copying inks. In one method the colouring matter of logwood extract is oxidised with potassium bichromate in the presence of alum, and a suitable proportion of acid added to give the desired colour.

In the paper read by Mr. Underwood before this Society in 1857, an ingenious method of copying was described, the principle of which was that of using a decoction of logwood as the ink, and moistening the writing with potassium bichromate before taking the copy. Under these conditions, the ink is only formed at the time of writing, and several copies can be made. This copying method was patented (Eng. Pat. 1112, 1857), and was adopted by Government offices and important firms, but, like all the other early copying processes, it has been to a large extent replaced by the methods of carbon paper and stencil duplication.

A modern development of the copying principle is to be found in the so-called copying-ink pencils, which are used widely, although they are now seldom employed for copying purposes.

These pencils consist essentially of a mixture of graphite, china clay and an aniline dye, which is usually methyl violet, whilst some also contain wax. The proportions of these different components vary widely in different kinds of pencils, and it is therefore possible to distinguish between the writing done with them. For instance, in the case of some of the pigments, ether will readily remove the dye, whilst other pigments contain sufficient iron to give a pronounced reaction.

By means of a series of tests applied systematically, it was possible in the case of *Rex* v. *Wood*, to prove that the pigment in the writing on some partly burned fragments of card was of the same kind as that in a copying-ink pencil found on the prisoner, and different from the pigments in some twenty other kinds of copying-ink pencils.

Inks which may have been used even prior to carbon inks are those made directly from the juices of plants, and used for marking linen, and at one time also as writing inks.

To this class belong the preparations obtained from various species of *Rhus*, such as *Rhus toxicodendron*, the poison ivy of North America, which is still used as a stain for leather, and the juice of different kinds of *Coriaria*, such as *Coriaria thymifolia*, the "ink plant" of South America, which changes from red to black in the course of a few hours.

But perhaps the best known of these natural inks is that obtained from the so-called "marking nut," the fruit of the Indian tree *Semecarpus anacardium*.

These nuts contain a viscid brown juice surrounding the kernel, and this, when extracted with ammonia solution, gives a dark fluid which produces a very permanent stain on linen. Lewis appears to have been the first to test the permanency of the stains (1763), and I can confirm his conclusions, for I found that the writing was fast to acids and alkalis, although the marks could be removed by means of ether.

Until comparatively recently the marking inks in most general use were those with a silver basis, frequently silver tartrate, which was reduced to a black silver oxide by the action of a hot iron. Inks of this type are still on the market, but are much less popular than aniline black inks. Inks containing gold and platinum salts have formed the subject of patents, but are obviously too expensive to be widely used.

One of the earliest types of aniline marking ink was that described by Jacobsen in 1867, which consisted of two solutions which were kept separate until just before use. One of these was a solution of aniline hydrochloride thickened with gum, and the other a solution of copper chloride, sodium chlorate and ammonium chloride. On applying the mixture of the two liquids to the fabric, a greenish stain, gradually changing to black, was produced, this being due to the formation of aniline black within the fibres.

Inks of this type are still to be bought, although they are gradually being displaced by aniline inks in one solution.

The principle underlying these inks is that of suspending the formation of the aniline black until the liquid evaporates, and it is by no means an easy matter to balance the two main constituents in such a way that the ink does not gelatinise into a solid black mass within the bottle. In some of these inks there is an excess of aniline over the oxidising agent, whilst in others there is both free aniline and acetic acid, but the exact composition and methods of making these inks are guarded as valuable trade secrets.

Some commercial inks contain salts of paraphenylinediamine, which is added to increase the black tone of the marking.

In examining marking inks the results of practical tests are of more importance than the composition of the preparation, although an analysis will show the general

character of the ink, and act as a control of the manufacturing process.

The analysis of a well-known silver marking ink gave the following results :—Water, 76.93 ; ammonia, 4.87 ; total solids, 23.07 ; mineral matter, 12.30 ; silver, 9.98 ; tartaric acid, 6.83 ; platinum, 0.26 ; substances insoluble in nitric acid, 0.11, and gum, 3.94 per cent. Extract of archil was present as the provisional colouring matter.

It is obviously a first essential that the ink should not injure the fabric. In the case of certain aniline inks which I have examined, the effect of applying dry heat too rapidly is to burn a hole in the material. This may be prevented by steaming the fabric or washing it with soap and water before applying heat, but one cannot always rely upon such precautions being taken.

The second requirement is that the ink should produce a permanent stain of a rich black tone. The tests to be applied include boiling strips of linen marked with the ink with soap and water, with strong sodium carbonate solution and with a dilute bleaching agent, and noting in each case to what extent, if any, the marking has faded.

The early history of printing inks was discussed by Mr. Underwood in the paper read before this Society, and I can confirm his observation that the ink used in the early block books is inferior to that found in the early books using movable type; apparently the latter contained a purer form of carbon.

The earliest block book in the British Museum dates back to 1470, and there is some reason to question the belief that block printing preceded the use of movable type, at all events in Europe. In all probability, printing ink, which was used either with blocks or movable type originated with the Chinese, who had only to add a drying varnish to their ordinary carbon writing ink to obtain a suitable medium for the purpose.

One of the earliest descriptions of the manufacture of printing ink is that given by Canneparius in his book *De Atramentis* to which I have already referred. This ink consisted of a mixture of lamp-black, linseed oil and juniper gum, which was heated over a slow fire until sufficiently thickened.

Moxon in his *Mechanick Exercises* (1683) states that Dutch printing ink of that date was superior to the English product, and he attributes this difference to the use in this country of too much resin and to the admixture of train (*i.e.*) blubber oil with the linseed oil, which caused the ink to become oily and to separate in the printed page.

Savage, who wrote on *The Preparation of Printing Ink* (1823), considered that Moxon was justified in his criticisms of the English printing ink of the seventeenth century, but asserted that the English ink of the early nineteenth century was much superior to the ink made by the early Dutch method. He considered it essential to carry the heating of the linseed oil to the stage technically known as "burning."

A standard ink based upon similar lines to Moxon's Dutch ink, was made by Breton, printer to the King of France, in 1751. The varnish was made by boiling nut oil (*i.e.*, walnut oil) for two hours, and then removing the cover so as to "burn" the oil, this process being repeated several times. The use of litharge was condemned as being liable to cause the ink to clog the type.

Since the day of Savage various modifications in the process of preparing the lithographic varnish have been devised, and it has been shown that the method of "firing" the oil is not an essential part of the process.

It is important to use an old well-matured oil for the purpose, for crude oil contains impurities which will interfere with the colour and the yield of the varnish. In this respect modern experience confirms the statements of the older writers, such as Moxon and Savage.

In some of the modern processes of making the varnish steam-jacketed kettles are employed, whilst in others the oil is heated by means of a steam coil, while air is blown into it through a series of small orifices. Varnishes made by heating the oil with superheated steam dry rapidly, but are often much darker in colour than those consisting of oil "boiled" by the older processes.

In order to prevent such discoloration in the preparation of the varnish, processes in which the oil is oxidised at a moderate temperature by means of oxygen are sometimes used, whilst in other processes ozone is used as the oxidising agent.

The substances which are introduced into the varnish, either to obtain a cheaper product or for some special purpose, include various resins, oil of turpentine, semi-

drying oils, such as soya bean oil, paraffin oil, "driers" of various kinds and soap. In the case of the so-called "gloss ink," a rapid drying copal varnish is often added.

The nature of the substances to be added will depend upon the use for which the ink is intended. For rapid newspaper work, for example, a cheap ink which dries rapidly is required, whilst for the finest book work a pure pale oil varnish is essential, and the rate of drying is of secondary importance.

The blacks used in printing ink range from common pigment such as bone black (made by calcining bones) or vine black, also known as vegetable black, which is obtained by carbonising vegetable material to pure carbon blacks, such as lamp-black and gas black. Modern lamp-black is prepared by processes analogous in principle to some of the early Chinese methods. It is made either from oil or from pitch, resin and the like. For example, in Dreyher's apparatus gas derived from vaporised resin is burned in a series of lamps beneath a rotating cylinder upon which the black is deposited, and subsequently removed by means of iron catchers coated with flannel. The best kind of lamp-blacks are obtained by a fractionating process analogous to that already described as being used by the Chinese.

The best kind of black is that commercially known as *gas black* or *carbon black*, which is now prepared in large quantities from the natural gas issuing from the oil wells in the United States. This is mainly made by the so-called "Channel" process, in which the gas is burned in a series of jets beneath steel channels grouped in tables of eight, and the black deposited on the smooth underside of these is scraped off into hoppers through a reciprocating motion of the channels.

Various factors, such as the pressure of the gas, the air supply and the speed of scraping, all have an influence on the quality of the product.

In examining gas blacks or lamp blacks, the "strength" or tinting power is determined by mixing weighed quantities with zinc oxide and oil, and comparing the tone with that given by a standard black under the same conditions, whilst the richness of tone (or colour) is compared in the same way with the standard black mixed in the same proportion with oil.

The carbon blacks upon the market vary considerably in composition. Analyses by Perrott and Thiessen (*J. Ind. Eng. Chem.*, 1920, 12, 234) show the following extremes: Amorphous carbon, 85 to 90 per cent., water, 1 to 7 per cent.; hydrogen, 0.5 to 0.8 per cent., and oxygen 2 to 8 per cent. Some degree of relationship has been established between the composition and the behaviour of the blacks in printing inks.

The mineral pigments commonly used for printing inks include vermilion for red; Prussian and other ferrocyanide blues, and ultramarines; chrome yellows, chrome greens, chrome yellow orange (a mixture of normal and basic lead chromate), orange mineral (a combination of lead oxides), Indian and Venetian reds, burnt umber and burnt sienna for browns.

In examining these, the tests to be applied include the colour, the covering power, fineness of division, miscibility with oil, and absence of grittiness. Organic lakes, consisting of dyes fixed upon a base such as alumina, are important pigments, and alizarine pigments and diazo dyes are superior in permanency to light to many of the mineral pigments.

The property of "bleeding" or forming a solution in the oil medium of the ink, is associated with some of the aniline dye lakes, and these are quite unsuitable for the manufacture of printing inks.

One of the main essentials in the preparation of printing ink is that the pigment should be an absolutely uniform state of fine division and be free from gritty matter, and that it should be perfectly and evenly incorporated with the oily medium. The more recent developments of the manufacture are in connection with machinery, such as grinding and incorporating mills, designed to effect perfect admixture.

As in the case of marking inks, the results of physical tests and of trials under the conditions for which the preparation is intended, are of greater importance than a chemical analysis, although this is sometimes necessary.

In addition to the properties already mentioned, practical tests should be made of the drying power, the flowing capacity, permanence to light and air, absence of "bleeding," or of "striking through" the paper, and the behaviour on the printing press.

The invention of the typewriter involved the production of a new kind of ink with properties intermediate between those of

printing and writing inks. Most of the machines on the market supply the ink to the type either by means of a ribbon or a pad, previously saturated or coated with the ink.

Many of the inks are still composed of a saturated solution of an aniline dye, such as methylene blue or methyl violet, with the addition of a suitable proportion of glycerin or other medium to give the necessary thickness to the solution, and to prevent its drying up completely within the ribbon or pad. In some of the inks the dye is used in the form of a lake.

An excess of glycerin is objectionable, since it causes the ink to yield smudged impressions, and this ingredient is, therefore, omitted in the best modern inks. One pad which I recently examined was saturated with methyl violet and a marine animal oil, probably menhaden oil. This was not a good medium for the purpose, as it did not dry with sufficient speed. The media used in other inks include mixtures of vaseline, oleic acid, castor oil, wax, etc.

Some of the black inks consist of a solution of nigrosine, whilst induline dyes are used to produce a very dark blue writing which resembles superficially the colour of a blue black ink in its later stages.

Most of these aniline inks are open to the objection that they give fugitive writing, and in some cases typed documents have been known to fade completely in the course of a few years. There are, however, numerous typing inks to be obtained which are much more permanent, and these contain finely divided carbon such as lamp-black or carbon black with, sometimes, also an aniline dye such as nigrosine. Finely ground mineral pigments, such as Prussian blue and vermilion substitutes, are also used in admixture with a mineral oil.

In the case of inks for ordinary correspondence, it is necessary that it should be possible to rub the writing out without leaving a smudge, but for record purposes the writing should be capable of resisting both chemical agents and mechanical treatment. Experiments which I made for one of the leading manufacturers indicated that it would be a great improvement if colloidal carbon were used in place of ordinary lamp-black for this purpose. In the use of such colloidal preparations of carbon is also to be found the solution to the problem of preparing a safety ink, that is to say, an ink which cannot be removed from a document without detection.

Acheson's colloidal graphite, which is made artificially and converted into a form in which it will remain suspended indefinitely in a liquid medium, is perhaps the best known example of this kind of carbon. Lamp-black can also be prepared in this form.

Several of the so-called safety inks sold in this country and in the United States contain a suitable proportion of this carbon pigment suspended in a solution of an aniline dye or other soluble colouring matter, and some of them, if left for a sufficient time before blotting, will penetrate well into the paper. A want of penetration is the weak point of many of these inks, which will resist chemical agents satisfactorily, but can be removed by mechanical treatment, such as brushing the surface of the paper under water.

Prior to the War, the so-called sympathetic inks, or inks for secret writing, were of very small importance. They had long been known, and were usually regarded as scientific toys. Even in the days of Pliny it was known that the juices of certain plants would remain invisible until heat was applied to the paper, causing carbonisation of the acids or carbohydrates in the juice.

Robert Boyle (1663) refers to some of these inks, and the use of salts of cobalt for this purpose was described by Waiz in 1715.

The solution of any salt which is colourless or nearly so, when applied to paper, but forms a dark compound on treatment with a reagent, can be used in this way. For example, an extract of galls would be practically invisible on paper, but would give a black ink on treatment with an iron salt, and so on.

During the War, various methods of secret writing were used by German agents, and particulars of the substances used were from time to time made public property, by being published in the press. For example, it was commonly known that the earlier agents were using the very primitive method of writing in lemon juice, although in the case of Kuepferle formalin was also used, probably since it has the effect of causing the writing to require greater heat for development. In that case, traces of formalin could be detected on the pen, actual vegetable particles were adhering to it, and the washings from the nib gave the reactions of a fruit acid, whilst on the other hand a cut lemon, found in the

accused man's room, gave a reaction for iron at the place where something had been inserted into it.

Later, it was also published that some of the agents had been using ferrocyanide, a solution of which salt is practically invisible on paper, but gives a blue Prussian-blue colouration with an iron salt.

The Germans were undoubtedly well acquainted with the principal methods of secret writing, for the methods of producing such writing and of testing documents to discover its presence are fully described in works on forensic chemistry published long before the War. For example, in Dennstedt and Voigtlander's *Lehrbuch der gerichtlichen Chemie* (1906), the methods of testing described, include treating portions of the document with dilute ink and exposing it to the vapour of iodine.

It is pointed out that ink is an effective developer for writing done with ordinary saliva, and that iodine vapour is the most generally useful reagent for every description of secret writing.

Experiments which I have made to ascertain the action of ink in developing saliva writing have shown that it is partly physical and partly chemical. By adding saliva to ink, the formation of Pelouze's insoluble tannate (containing 8 per cent. of iron), is accelerated, and thus ink will darken more rapidly at the point where the saliva has dried upon the paper.

At the same time, if the surface of the paper has been scratched, there will be increased absorption of colouring matter where the sizing has been removed, so that in that case the development is also a physical process.

I have not, however, found any reference in German scientific literature to the use of solutions of colourless substances which become fluorescent under the influence of ultra-violet light. I called attention many years ago to the advantage of such a method, in the first edition of the book on *Inks*, which I wrote in collaboration with Mr. T. C. Hepworth.

NOTES ON BOOKS.

THE JOURNAL OF THE INSTITUTION OF ENGINEERS (INDIA). Vol. II. April, 1922. Calcutta: D/5, Clive Buildings.

This volume contains a record of Proceedings of the second General Annual Meeting of the Institution, which aims at fulfilling, for India, the functions fulfilled for England by the corresponding Institution in England, or for America by the American Society of Civil Engineers.

From the report and statement of accounts for the year ending 31st August, 1921, it appears that the Institution of Engineers (India) has not yet arrived at a condition of assured stability, its members (or subscribers) amounting to only 421 so far, as compared with an estimated requirement of 780 members for purposes of financial stability. The Institution is, however, still in its infancy, and its organisers are confident of ultimate success, a confidence which we cordially hope will be justified by events.

Amongst the professional papers read at its second Annual General Meeting on the 30th January, 1922, the place of honour has been accorded to an interesting monograph by a non-engineer—a geologist, Mr. Cyril S. Fox—on "Some Engineering Aspects of Geology."

The greater portion of his paper is devoted to a discussion of rocks (as distinguished from agricultural soils), minerals, structural geology, stone-quarrying, stability of hill-slopes, stability of artificial tunnels and dams; and these subjects he discusses obviously as an expert, with a facility of lucid illustration which will probably be useful to, and much appreciated by, young civil engineers.

Here and there in his paper we find occasional slips; as, for instance, where he mentions Viceregal Lodge, at Simla (instead of the Town Hall, Simla), as an example of a building, the stone for the construction of which was not selected with sufficient care before it was utilised for that purpose.

Another good paper, in the same volume, is one on "The Water Supply of Bengal Towns," by Mr. J. Bransby Williams, M.I.E. (Ind.), Chief Engineer, Public Health Department, Bengal.

Mr. Williams explains that the peculiar difficulty of urban water supply projects in Bengal is that supplies are limited by financial considerations in a manner that is not experienced in countries with a higher standard of living and individual wealth.

In illustration of his meaning, he assumes statistics of a waterworks installation in an average *mofussil* (country town) in Bengal. The capital cost of the works is Rs 2000 (£133) per 1,000 gallons of water supplied daily throughout the year; and working expenses threepence per annum for the same unit of supply. It is customary for the Local Government to present the municipality with a free grant of one-third of the capital cost, so that the latter has to find capital to the extent of £89 only per thousand-gallon unit. Expenditure has to be incurred annually to the extent of 7½ per cent. of the capital cost, in interest charges and liquidation of capital; and this amounts to 4½ pence per unit per annum. Thus the total annual cost of water supply is 7½ pence per unit. The rateable value of the town is less than 16

shillings per head, and the maximum water rate that can be levied is 6½ per cent. of rateable value, or, say, 1¾ shillings per head per unit of supply per annum; or 1¾ pence per mensem; or 0.057 pence per diem. And the maximum quantity of water that can be supplied (consistently with sound finance) for that sum of money would be $\frac{1000 \times 0.057}{7.34}$; *or rather less than 8 gallons per head per diem.*

On the other hand, the members of Bengal municipal bodies point to the fact that the allowance of water in London is from 40 to 50 gallons per head per diem, and in some American cities over 200 gallons; and they argue that in a tropical climate like that of Bengal a supply of 15 gallons per head per diem ought not to be regarded as excessive. To reconcile financial considerations with arguments of this sort: "*Hic labor, hoc opus est.*"

Mr. Williams's remarks on the subject of subsoil water flow seem to be generally sound.

The only other paper we need notice here is one on "Hydro-Electric Power in Mysore," by Mr. S. G. Forbes.

Mr. Forbes is apparently an electrical engineer and a hydro-electric enthusiast. He starts by quoting from a report written by himself in the post-war enthusiasm of 1918:—

"The Great European War has taught . . the tremendous importance of the industrial development of all the resources of the nation until all the needs for carrying on the peace-business of the nation, and if necessary for conducting an aggressive and successful war, can be met to the fullest extent possible from those resources within the nation . . . . Probably the most important single question arising out of these investigations is the conservation and economical use of our resources of coal, oil, and wood. These resources are not inexhaustible, and we are using our capital when we consume them, for whatever purpose, and we should . . bend our energies towards . . . the substitution therefore of power derived from some other source." Hydro-electric power suggests itself as this other source; and Mr. Forbes gives a description of the Cauvery Power Scheme in Mysore "as an illustration of what may be done with a potential water power situated within a reasonable distance of an industrial centre, and also because it is one of the very few 25-cycle systems in India."

He compares the progress of hydro-electric power development in Mysore with that of the Province of Ontario, Canada, and with that of the whole of the United States of America; and he goes on to write :—

"Most of the water-power in Mysore, by reason of the present stage of industrial development and price of fuel, is not economically available. It simply represents a potential asset to be made available as the price of fuel increases and industries are forced to take it up. The increasing cost of fuel, so long ago as 1900, forced the development of the Cauvery Falls, and the transmission of the power 92 miles to the Kolar Gold Fields, where it was used to displace steam power. . . . The steady decrease in the supply of fuel and its corresponding increase in cost has been so active in Mysore and Bangalore that power from fuel has been almost completely displaced by hydro-electric power, releasing the fuel for domestic purposes and such industries as inherently require fuel for heat. The electrification of the railways is under investigation, and when the conditions of traffic and fuel costs justify, the change from steam to electricity will be made."

All this is interesting and instructive. Mr. Forbes's account of the development of hydro-electric power in Mysore is a history of progress on sound commercial principles. So long as coal or wood fuel was available at economical rates of cost, the Mysoreans used it for all purposes; but when these kinds of fuel became scarce, and their prices prohibitive, the business enterprise of the local industries substituted cheaper power derived from hydro-electricity. This being so, one is not quite prepared to follow the further development by Mr. Forbes of his views, as follows:—"The development of hydro-electric power has been brought about by economic conditions which, until the War, were not fully understood, or to which we did not give sufficient heed. The sooner we get rid of the idea that such undertakings are investment schemes, and realise the conditions that are compelling us to economise, the better it will be for the fuel supply of the future generations."

Apparently in Mr. Forbes's opinion, the development of hydro-electric power in Mysore has been on the wrong lines and on economically false principles. His idea appears to be that even if there had been, down to the present day, plenty of cheap wood and coal fuel in Mysore, the people should have refrained from using it, and should have kept it in reserve as "capital," with a view to the possibility of the utilisation of it at some future date, by a future generation of Mysoreans in the prosecution of an "aggressive and successful war." In the meantime, they should have developed (and paid for) hydro-electric power at a greater cost and kept their wood and coal "capital" idle for the benefit of future generations. This seems to be rather an extreme illustration of hydro-electric enthusiasm; likely to be less convincing in the year 1922, than it might have been in 1918.

It is probable that neither in America nor elsewhere in the world has hydro-electric power been developed on a large scale, except in cases and places where it could be produced at a cost low enough to enable it to compete successfully

with power generated by wood, coal, oil or other source of energy Mr. Forbes's sketch of the hydro-electric installations in Mysore is interesting, but his reference to this enterprise seems to be mainly an argument of propaganda in favour of hydro-electric power development regardless of cost

Other papers in the Journal are entitled: "Organisation of Ordnance Factories," "Subsoil Percolation," and "Flood Absorption in Tanks."

GENERAL NOTES.

INDUSTRIES OF THE ISLAND OF GOZO — The Island of Gozo, the smaller of the two inhabited islands of the Maltese group, has an estimated population of 24,080, and an area of 20 square miles, most of which is devoted to agriculture. Clover, grain, and cotton were the principal crops raised during 1920-21. There was a large quantity of eggs exported for consumption in the island of Malta. In previous years a considerable quantity of wine was exported to Malta, but, according to a report by the United States Vice-Consul in Malta, the vineyards gave a poor yield last season. The other local industry is lace making, which, for the last five years and up to the present time, has been on the decline owing to the scarcity of demand in foreign markets

DEVELOPMENT OF BRAZILIAN OIL NUT RESOURCES.—A bill has been introduced into the Brazilian Congress providing for the protection and development of the oil-nut resources of the country The numerous varieties of nuts growing in the northern sections of Brazil have high oil content and are in demand because of their food value and lubricating properties. According to a report by the United States Assistant Trade Commissioner at Rio de Janeiro, an important trade could be developed by the proper culture and handling of these nuts, and it is to this end that an experiment station is being proposed.

VALUE OF THE POULTRY INDUSTRY IN THE UNITED KINGDOM.—In 1920, according to the *Journal of the Ministry of Agriculture*, the United Kingdom imported eggs and poultry to the value of £18,759,656, exclusive of imports from Ireland. Irish exports were valued at £18,236,406 in 1919, the bulk of which came to Great Britain. Thus the value of eggs and poultry imported into Great Britain during 1920 probably reached the figure of £36,000,000. The value of eggs and poultry produced in the United Kingdom in 1920 is believed to have been between £50,000,000 and £60,000,000, whereas the estimated value of the wheat crop in the United Kingdom for 1920 was approximately £31,000,000.

VICTORIA AND ALBERT MUSEUM. — The Victoria and Albert Museum has acquired, by gift, the throne of the Emperor Ch'ien Lung. The Museum was given an option of purchase on exceptionally favourable terms, but its resources were unequal to so large an undertaking; fortunately a private donor, Mr. George Swift, has provided the whole of the sum required The throne was one of a pair, formerly in the Palace of Nan-Haidze, near Pekin, its companion being, it is believed, in the possession of the President of the Chinese Republic. It was made in the Imperial Lacquer factory maintained by Ch'ien Lung for that Emperor's personal use With the exception of the seat, which is of fine flat red lacquer with floral decoration, it is executed throughout in carved lacquer of superb quality and workmanship, mainly red, but with layers also of green in two shades, brown and yellow The decoration is symbolical throughout, of good fortune, longevity, married felicity and other matters of good omen: the centre panel of the back having for its chief feature the elephant bearing a vase of jewels—a rebus signifying "Peace reigns in the North" The throne is 3ft 11ins in height, 4ft 1¼ins in width and 3ft in depth; and the seat is still furnished with its original cushion of fine old brocade

INDIAN CINCHONA BARK AND MYROBALANS — A new volume in the series of Reports of the Indian Trade Enquiry conducted at the Imperial Institute, published by Mr John Murray, deals with cinchona bark, the source of quinine, and myrobalans. At the present time Java has a virtual monopoly in the production of cinchona bark, its closest competitor being India, which produces only about 8 per cent of the world's supply Moreover, the manufacture of quinine is largely under the control of Dutch interests, and of the 8,000,000 oz. used annually in the British Empire about 5,000,000 oz have to be obtained from foreign sources It is suggested that attempts should be made to produce in India sufficient bark to meet a much larger proportion of the Empire's requirements Cinchona has been introduced into several tropical parts of the Empire, and the volume records the results of examination at the Imperial Institute of cinchona bark grown in St. Helena, Tanganyika, and the Cameroons. Myrobalans, the dried fruits of a large tree, form one of the principal tanning materials used in India and are also largely exported The quantity reaching this country has varied in recent years from about 500,000 cwts to over 800,000 cwts., whilst prior to the war Germany and the United States were also large importers. Particulars are given in the Report as to the trade in myrobalans, their composition, and their use by British tanners and dyers, whilst suggestions are made with respect to the future trade in this product.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING

WEDNESDAY, 26TH APRIL, 1922.

SIR JOHN F. C. SNELL, M.Inst.C.E., Chairman of the Electricity Commissioners, in the chair.

THE CHAIRMAN, in introducing the reader of the paper, said that after the great world cataclysm through which we had passed, anything which was done by our great Societies to make industry more efficient and intelligent was worthy of most grateful acknowledgment The cataclysm had left us in the material sense a poorer nation, recalling to some extent the condition which obtained at the close of the Napoleonic wars, when, but for one thing, the nation would never have made the recovery which it did That one thing was the invention of James Watt It was the utilisation of steam which enabled the country to develop into the great industrial position which it had since reached. The position to-day, however, was not analogous because since the Napoleonic wars other nations which were active industrial competitors had arisen The question was what could be done to-day to bring about a similar revival of industry to that which took place after the Napoleonic wars He would not suggest that it was wholly electrical development which was going to do this, but certainly this was going to be an important factor Anything, therefore, which encouraged manufactures and commerce must be of material assistance at this juncture to the nation at large He welcomed such a paper as was proposed for that evening as contributing to that revival. Dr. Crowley was a colleague of his on the Electric Power Supply Committee during the war, and it did not take his colleagues on that Committee very long to size up his great capabilities, and it was with the greatest pleasure that later he (the speaker) was able to welcome Dr. Crowley as a member of the Water-Power Resources Committee. He was reminded of a character in *Westward Ho!* who said that the reward for being faithful over little things was to be found in having greater things to do, for Dr. Crowley was rewarded by being made Chairman of two sub-committees which really did most of the important work of the main body. Those who had seen the report of the Water Resources Committee would realise the immense amount of work which must have fallen to his lot. It was with the greatest pleasure, therefore, that he introduced him to the meeting and called upon him to read his paper.

The paper read was:—

THE USE AND ADVANTAGES OF ELECTRIC POWER IN THE FACTORY, AS ILLUSTRATED BY ITS APPLICATION TO THE JUTE INDUSTRY.

By J. F. CROWLEY, D.Sc., B.A., M.I.E.E.

SYNOPSIS.

I. General

II. The alternatives open to manufacturers as regards power.

(*a*) To purchase power from outside sources.

(*b*) To generate power themselves The choice open to the manufacturer decided mainly on the basis of cost; but there are the following points in favour of outside supply:—

(1) It leaves more capital available for textile plant. (2) Enables the management to concentrate on manufacturing processes (3) Permits of easy and gradual expansion to meet requirements (c f. mobilisation for munitions in Great Britain)

III. Where the manufacturer generates power himself, the principal prime-movers he has to choose from are:—

(1) The Steam engine (2) The Steam turbine. (3) The Diesel engine

Shows how a steam turbine best meets the driving criteria laid down.

IV. The principles governing power applications.

(*a*) Building requirements must be little, if at all, in excess of those required by the manufacturing processes.

(*b*) It must be possible to arrange lay-out of plant to best suit manufacturing processes, lighting, accessibility and supervision.

(*c*) The equipment must be reasonable in first cost and in running costs.

(*d*) It must be possible to secure the maximum production from the machines.

(1) By ensuring reliable running. (2) By maintaining the average speed within the defined limits. (3) By keeping the "cyclic irregularity" within the defined limits.

V. How the driving principles laid down are affected by :—

(1) External conditions such as climate. (2) The nature of the manufacturing processes. (3) The peculiarities of particular machines.

VI. The importance of an exact knowledge of the requirements of an industry and its manufacturing processes when applying electrical drive in accordance with the principles laid down.

VII. The jute industry and jute manufacturing processes with their respective power requirements.

VIII. Methods of distributing and applying the power in the factory.

IX. Shows how electricity best meets the driving criteria laid down, keeps shafts within reasonable dimensions and speed variation within any limits desired. Shows how electricity can be as bad as the worst mechanical drive or better than the best, depending on how it is applied.

X. The application of electricity—

(*a*) Group driving in large units.

(*b*) Group driving in small units.

(*c*) Individual driving.

The best combination of all these depends on each individual case.

XI. Increased production the only salvation for factories put down during or since the war with high capital charges. The real advantage of electricity lies in the increased production resulting from its use, and indicates how a given increase in production affects profits.

XII. Special considerations applying to India.

XIII. Conclusion.

The statement was made a few years ago in the report of an important Government Committee* that "one question which has been settled conclusively during the past 15 years is that the most economical method of supplying power to industry is the electric motor, which, on account of its high efficiency, has ruled out all rivals so far as the workshop itself is concerned."

The author felt at the time this report was issued, and still feels, that this and similar statements were of too general and far-reaching a character and unlikely to be accepted without evidence by the bulk of moderately large power users. Both engineers who are engaged in developing the power loads of electricity supply stations on the one hand, and in promoting the sale of electrical manufactured goods on the other, realise very fully that in general where the problem of driving is under consideration by manufacturers, a strong case has to be made in each instance on economic grounds for electricity, before the manufacturer can be induced to adopt it in preference to installing his own prime mover with mechanical methods of power transmission. Further, in the majority of cases where electricity is adopted in the factory, its adoption is not based on a saving in power due to motor efficiency or on a reduction in transmission losses, nor even on the grounds of cheaper power costs, but because of an increased output from the manufacturing plant which inherent qualities in electrical transmission enable the application of electricity to give.

During the last few years, owing to the action of the Government in appointing on the report of the Electricity Supply Committee of the Board of Trade, Commissioners with comprehensive powers to deal with electricity supply, there has been a very distinct development in the provision for Great Britain of a cheap supply of electricity from central sources. This development has definitely accentuated a tendency already apparent for power users to purchase power from public supply authorities, rather than generate themselves, in other words, towards the "collective method" as distinct from the "individualistic method" of producing power. That this is a movement in the right direction all engineers are agreed.

It is only by opening up new fields for the use of electricity and developing its application to each and all of the industries which produce the wealth of the country that the market for it can be extended and broadened and its cost as a marketable commodity further reduced to the consumer. In the present paper the author has attempted to indicate the advantages electricity has in the factory, and to show that if its installation is properly carried out that it is, in general, the best method of applying power. With a view to illustrating the underlying principles of power application, an industry of growing importance to India and to Scotland, the development of which is wholly due to British enterprise, and which is still almost wholly in British hands, will be described and the application of power to it considered.

* Reconstruction Committee, Coal Conservation Sub-Committee on Electric Power Supply in Great Britain, April 16th, 1917.

THE SOURCE OF POWER.

As already indicated, the manufacturer has in regard to the power he needs two courses open to him :—

(*a*) To purchase power from outside suppliers.

(*b*) To produce power himself.

In regard to the first, in many parts of the country, notably in Lancashire, Yorkshire, Nottingham, Leicester and the woollen districts of Scotland, it is possible to purchase mechanical power under those "Room and Power" schemes which have done much for the starting of new industries in this country. In the case of a factory the author visited recently, some twenty manufacturers occupy one large building, buying room and power from the proprietor. Apart from "Room and Power" schemes, however, the only power it is open to the manufacturer to purchase is in the form of electricity. The decision of the manufacturer on this matter is in the main a commercial proposition governed by a comparison between the price at which power can be privately generated and electricity purchased. It should be affected, however, by important considerations, to which a commercial value can only be given with due regard to individual conditions. It can be claimed that the purchase of power leaves capital available for a more remunerative investment in manufacturing machinery; enables the management to concentrate its attention on the purely manufacturing side and permits of a gradual expansion of manufacture to meet demands, since all that is needed for such expansion is the purchase of further motors. This latter advantage was particularly noticeable in connection with the mobilisation of industry for munition purposes during the war. It is safe to say that without the adequate supply of electricity Great Britain had available, the steady growth in the manufacture of munitions which was so necessary to the success of the war could not have taken place. It is stated that 95% of the new factories put down for the manufacture of munitions were electrically driven.

The further important point may be made in connexion with the public supply of electricity that there is, as has been pointed out, a steady tendency towards the taking of power from central power stations, and that as the load of these stations grows in amount and diversity, their generating costs are certain to fall. The cost of coal per unit generated is only one of the items affected by an improved load factor, and it was shown recently that an increase in load factor in a Dutch station of from 40% to 56% would reduce the coal consumed per Kelvin from 1.87 to 1.7 lbs.

It need scarcely be pointed out before leaving this part of our problem that the merits or demerits of Electrical Driving are not determined by a decision as to the purchase of power. The manufacturer who decides to make his own power can convert that power into electricity for power distribution throughout his factory.

Electricity for public supply purposes is in general distributed at high pressure for large industrial loads and at low pressure only for lighting and small industrial applications. For distribution to the motors in the factory it is usually reduced to a moderately low standard pressure such as 500 volts. This is done by means of static transformers which are sometimes placed in a sub-station from which a number of mills are supplied, or more generally separate transformers are provided for each factory. It should be pointed out here that some public supply companies in India so arrange the terms on which they supply current as to offer strong inducements to manufacturers to avoid the installation of transformers and apply high tension current direct to the motors. This is a practice which in general cannot be too strongly deprecated. High tension motors suffer from several drawbacks where ordinary industrial power applications are concerned. They have perforce to be of large size since small motors cannot be built for high pressure, while because of the element of danger attending their use it is not always possible to place them in the best position from a driving point of view. These disadvantages tend to nullify the flexibility in application of electricity for driving, which, in the author's opinion, forms its greatest claim to consideration.

A practice also that appears to be developing in India in connexion with the public supply of electricity is the undue penalising of the manufacturer if the power factor of his installation fails to reach a certain figure. This clause in electricity supply contracts is working out in practice in a manner that the supply engineers can scarcely have anticipated. The manufacturer, knowing that he is liable to suffer

a severe penalty if not to have his power cut off if his power factor does not reach the value fixed by the supply company and being informed that large motors have a higher power factor than small motors and high speed motors than slow, is induced to put down large and frequently high speed motors. This again destroys flexibility and operates against the use of motors of a sufficiently low speed to be direct coupled to line shafting.

A more general adoption throughout India of the system in use in Calcutta is desirable, by which the reduction in power costs that would accrue to the supply company from an increase in power factor is calculated, and the greater part of the saving is credited to the consumer in the form of reduced charges, a corresponding provision being made for an increased charge for a low power factor. The author is informed that under the arrangement now in force it would pay a customer to instal apparatus to raise his power factor since by so doing he would get a reduction in current charges that would pay a dividend on his investment. Without such an equitable contract the supply company stands to gain and the manufacturer to lose by a too rigid adherence to standards which may militate against good engineering. Any restrictions that tend to make the application of electricity less flexible tend to make its adoption less rapid.

Apparatus to improve power-factor may be installed in the central power station or in the factory itself, preferably in the factory, which is the seat of the trouble. The following are the more usual methods of improving power-factor :—

(a) Static condensers.
(b) Synchronous Motors.
(c) Synchronous Asynchronous motors.
(d) Phase-advancers.

When the manufacturer decides to put down his own power plant he has in practice three types of prime-mover to choose from :—

(1) The modern reciprocating steam engine.
(2) The steam turbine.
(3) The Diesel or the semi-Diesel engine.

Neither the Diesel nor the semi-Diesel have even in India in close proximity to the oil fields made much progress in industry. This is perhaps due to the comparatively large load furnished by individual mills, the expert attention required by this class of engine, and no doubt also to the speculative nature of the price of oil.

The development of fresh oil-fields, a greater steadiness in the price of oil or improvements in the engine may lead to its greater employment. The author sees no reason to anticipate such a development, however, and feels that any cheapening of the price of oil would lead rather to its use as a fuel for steam boilers for which purpose it is finding a considerable outlet at present.

The real fight for supremacy in millwork lies between the reciprocating steam engine and the steam turbine. The steam turbine is smaller and lighter than the reciprocating engine ; it can be housed in a smaller building and requires lighter foundations than its rival ; its first cost is lower, and assuming that a good vacuum is maintained, and that the size of unit is not too small, its power costs are lower also. It is, however, when we come to the principles that should underly the application of power that the most signal advantages of the steam turbine begin to appear. The turbine being a high speed rotary engine instead of a slow speed reciprocating engine, provides a turning torque on the shafting which is without cyclic variation ; a fact which contributes very largely towards the attainment of high standards for speed variation and cyclic regularity through the factory system. Taken in conjunction with the other factors mentioned, it has led to the growing adoption of the steam turbine as the prime mover for private installations. It should be generally recognised, also, that so far as power production on a large scale is concerned, the steam turbine is supreme in all cases where water power is not a serious competitor. Its almost universal adoption by central station engineers whose business is the maintenance of a reliable supply of power at a low cost, may be taken as a clear indication that it has proved itself to be the most satisfactory prime-mover and, in the author's view, its exclusive adoption for all factory installations exceeding 1,000 kw., when power is not purchased, is only a matter of time.

THE PRINCIPLES OF POWER APPLICATION.

It cannot be too clearly emphasised that the production of a manufactured article of a quality and at a price to compete is the primary if not the only objective of the

manufacturer, and that power is only one of the many agents he employs to secure this end. With this in mind, the following broad principles may be laid down as governing its application :—

(*a*) The building requirements for power purposes must be little, if at all, in excess of those required by the manufacturing processes.

(*b*) There must be no interference with the lay-out of the manufacturing plant to suit the manufacturing processes, lighting, accessibility and supervision.

(*c*) The power equipment must be reasonable in first cost and in running costs, and finally,

(*d*) It must be possible to secure the maximum production from the machines :—

(1) By ensuring reliable running.

(2) By maintaining the average speed of the machines within the recognised limits.

(3) By keeping the cyclic variation in speed of the shafting within defined limits.

(4) By facilitating prompt starting in the case of machines that start and stop frequently.

These are the basic principles that it is now recognised should govern every application of power to industry, and it may be said at once that the engineer can to-day satisfactorily meet each one of them, and that no reason exists on engineering grounds for any departure from their rigid application. When we proceed, however, to deal with matters quantitatively, we find these are affected by :—

(1) External conditions, such as climate, etc.

(2) The nature of the manufacturing processes ; and

(3) The peculiarities of the machines to be driven.

Power requirements are affected by humidity and by temperature, which, by altering the tension of ropes, belts and spindle driving bands in textile installations and the viscosity of the lubricating oil, seriously influence the power required and, indirectly, the speeds of the machines. This effect is most serious in the morning and after week-end stops, and in India is particularly noticeable during the Monsoon, when, occasionally, the increase in tension of the driving ropes and bands produces a load with which the engines have difficulty in coping.

The nature of the manufacturing processes and of the particular machines employed also influence to a marked degree the limits of speed variation it is desirable or practicable to lay down.

Speed limits that would be reasonable in a textile factory where the material runs through continuously could not be obtained in a tannery where separate hides have to be successively passed through the machines, nor would it be possible to obtain that degree of regularity in the driving of a mangle or a loom that might reasonably be anticipated with a ring or a flyer frame.

As regards the first requirements governing the application of power little comment is needed. Any excess in building specially required for power generation or application means additional capital expenditure, not directly remunerative. This may become serious if, for instance, large motor alleyways are insisted on, and in cases where only a limited space is available the productive capacity of the manufacturing plant may be seriously reduced.

With regard to the layout of the manufacturing plant, this should be carried out on the lines that best suit the manufacturing process and economical production. It is, for instance, in general desirable that, so far as possible, the raw material should enter at one end of the building and pass through without interruption to the packing and forwarding departments. The driving system should permit of this being done and should not, in any way, by reason of shafting requirements, etc., interfere with the internal economy of production.

The older mechanical drives where heavy bevel gears and other mechanical transmission devices were employed did interfere, to a serious extent, with factory layouts, and prevented the adoption of arrangements best suited to manufacturing conditions.

The equipment for driving, also, must not be excessive in first cost, because here, too, it should be noted that any capital expended on ancillary machinery, such as the power equipment really is, is capital that could be usefully employed on the productive side.

The requirements we have just been considering are intended to secure that the maximum amount of productive plant is obtained from the capital available, and

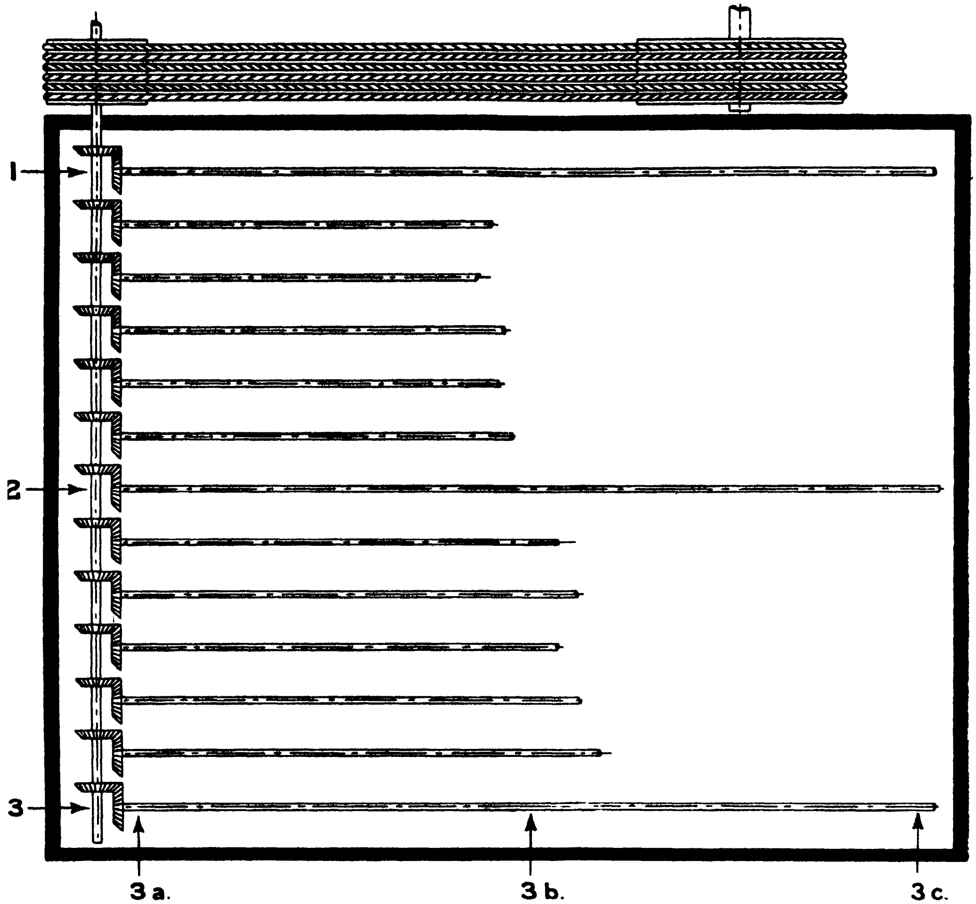

FIG. 1.—Layout of Shafting in Weaving Shed (Bombay).

we have now to consider how far the maximum production can be obtained from the manufacturing plant actually installed. This is secured, in so far as it depends on the power plant and transmission system, by having a reliable installation not subject to stoppages and by securing that as steady a speed as possible is maintained throughout the factory.

Where a steady running prime mover drives directly a machine which does not provide a cyclic variation in load, the speed of the shafting and transmission system generally should be perfectly uniform. In no system, however, is it possible to secure such uniformity, and it becomes necessary to consider what variations occur and within what limits those variations can be kept. The variations usually met with arise from three causes—

(*a*) Irregularity in turning movement of the prime mover.

(*b*) The starting and stopping of individual machines on a line shaft.

(*c*) Cyclic variations in torque of individual machines.

The effects produced by irregularity in turning movement of the prime mover are two-fold–

(*a*) Variations in average speed of long period due to variations in load, or to poor governing.

(*b*) Cyclic variations due, for instance, to reciprocating moving parts.

Governing and regulation have been so far improved that it is now possible to maintain the average speed of an engine within sufficiently fine limits, and the real trouble in factory drives is found to arise from rapid fluctuations in speed which are superimposed on the average speed. These speed fluctuations, which are generally of high frequency, are commonly referred to

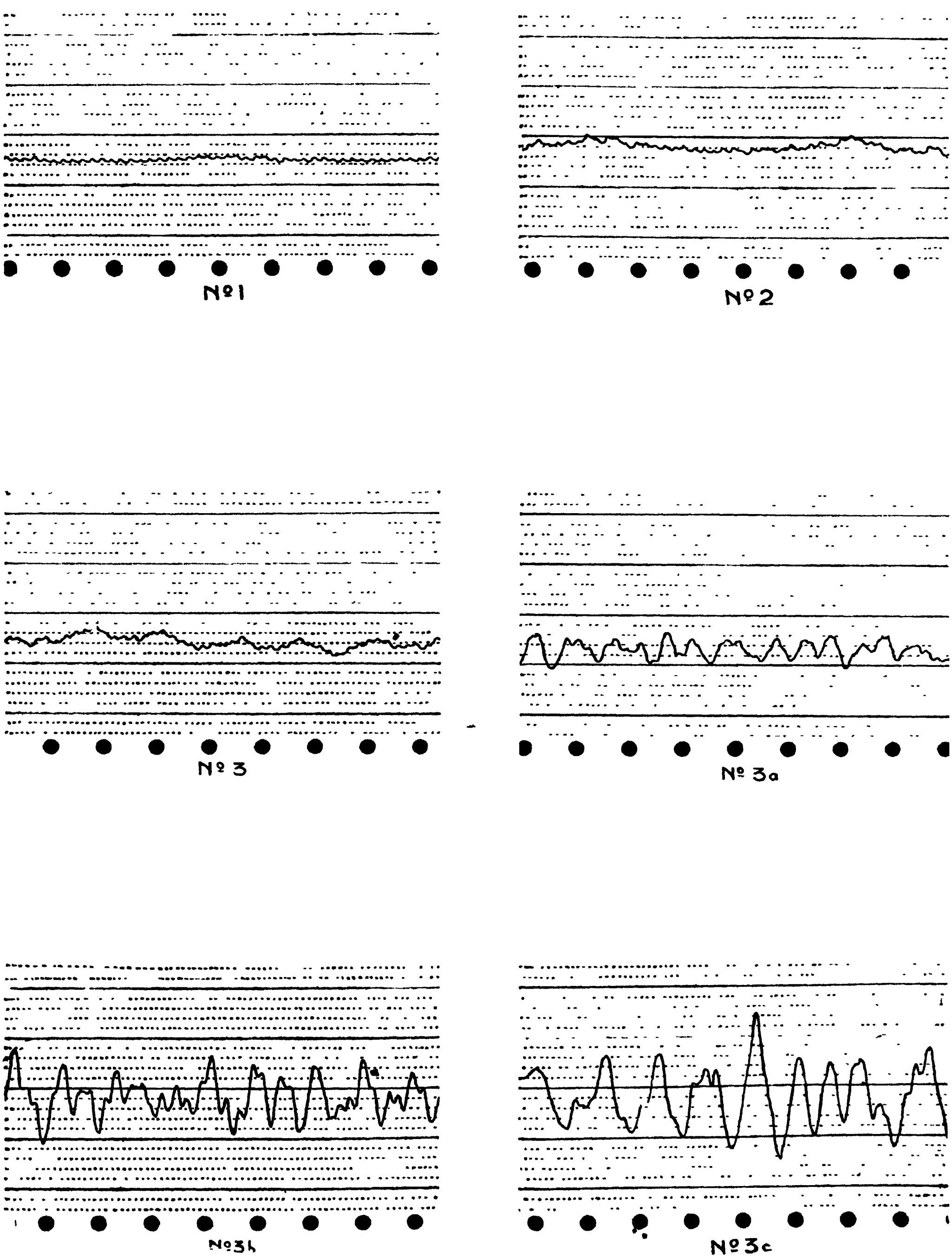

FIG. 2.—Tachograph readings in Weaving Shed (Bombay).

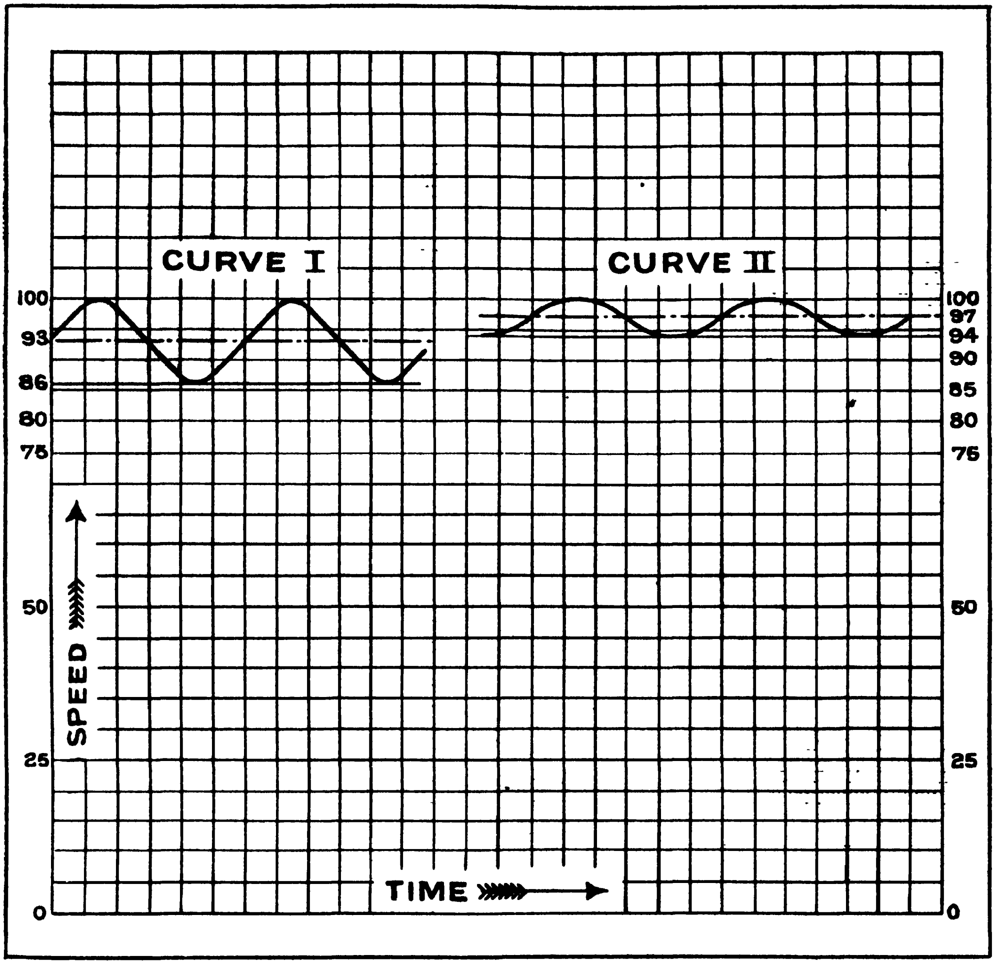

FIG. 3.—The Effect of Cyclic Variation in Speed.

by mill engineers under the heading of "cyclic irregularity."

It may be desirable at this stage to consider permissible limits for speed variation based on experience of what can be obtained and is obtained in practice in textile work. A short time ago in a series of articles* published in the *Textile Recorder*, a writer, evidently with experience, maintained that with modern systems of governing and regulation, it should be possible to keep the speed variation of a reciprocating steam engine within 1% and 1½%, and that a variation beyond 1½% to 2% should not be tolerated. He found that at the driven end of the first motion shaft the speed variation had usually increased to a much higher figure, such as 5%, but that it should be possible to design the layout so as to keep it below 3% at this point and that a higher figure should not be permitted. Proceeding now along the shaft from the driven end he found a steady increase in speed variation until at the extreme end figures varying from 9% to 17% were reached.

It was found, however, that when the speed variation at any point exceeded 6½%, the effect on the spinning was distinctly noticeable and weaving on automatic looms was impossible. This writer, therefore, gave 6½% as the maximum permissible speed variation that should be allowed in any part of a textile mill.

The figure was clearly what the writer felt he could hope to obtain in a mechanically driven mill, and the fact that he was willing to permit of a speed variation, the harmful

* *Textile Recorder*, Manchester, Feb. 15, 1911, to Feb. 15, 1912

effect of which was noticeable on the machines, was clearly because he had little hope of obtaining better results in mills driven on the older systems. Tests the author took in India in a good factory have shown that a speed variation of 1% near the engine became 3½% at the beginning of the furthest loom shaft, 9% at the middle of the shaft and 14% at the end. Fig. 1. shows the lay-out of the shafting in this factory and indicates the points at which the readings were taken, while Fig. 2. shows a photographic reproduction of the actual readings themselves, the small vertical scale divisions corresponding to a speed variation of 1% and the distance between the horizontal points corresponding to three-quarters of a second or six seconds over the scale. The difference in the speed variation at points 3 and 3a is specially to be noted, and also the rapid increase in speed variation at 3b and 3c. The author ventures to say that at no part of a mill shafting system should the speed variation exceed 3% to 5%, and he looks forward to the day when every industrial power system will be tested and passed for speed variation on a standardised basis, to limits such as these, before being taken over.

The effects of speed variation as shewn by experiments are that when it exceeds a certain limit some machines cannot be run at all, the production of other machines, and in particular of spinning machines, is affected through breakages, and the production of all machines is reduced below the maximum of which the machines are capable for reasons that will be clear from the diagram shewn in Fig. 3. The first curve, I, in this diagram shows a speed variation of 14%, giving an average speed of 93% or 7% below the maximum speed attained. The second curve, II, illustrates an attempt to improve the drive and shows a speed variation of 6%, giving an average speed of 97% or only 3% below the maximum. The fall in average speed illustrated by the first curve represents a direct loss in production of 7%, and is a feature of speed variation, to which all too little attention is given. The same remark applies to the progressive character of the speed variation from the engine to the extreme end of the most remote line shaft. From a manufacturing point of view the rapid oscillations of shafts which result in the speed variations, we are now considering, are more serious than the slow variations in average speed to which reference was made earlier, and are produced in the main by the starting and stopping of machines and by the irregular torque of individual machines. For a given thickness of shaft they are less with fast shafts than with slow and with short shafts than with long. They are, on the other hand, stimulated by any cyclic variation of speed of the prime-mover.

The author believes that many of the mistakes made in connection with the application of power to particular industries are due to a lack of knowledge on the part of those making the application, of the processes employed, and of the peculiarities of the machines used and to a lack of appreciation also of the needs of the industry and of the personal equation of those employed in it. He feels, therefore, that he need offer no apology for entering in some detail into these elements, choosing for this purpose an industry which furnishes problems to the power engineer typical of those he is likely to meet with in most textile industries and in many industries of a similar character.

THE JUTE INDUSTRY.

Close on 90 per cent. of the world's jute is grown in the Presidency of Bengal, the principal supply coming from the northern and eastern belts. Behar and Orissa come next as a source of supply, followed by Assam, a small contribution being made by the State of Cooch Behar.

The output of raw fibre for the past 20 years has varied from 6½ million bales to 10½ million bales per annum, the latter record figure being reached in 1914. This is sold at a price which fluctuates considerably, varying during the war for instance, from Rs.35 to Rs.75 per bale. For statistical purposes it may be taken at an average of Rs.50 per bale.

Somewhat less than one-half of the jute crop was exported in a normal pre-war year, the United Kingdom taking about one-third of the exported raw material, Germany about one-sixth, the United States somewhat less and the bulk of the remainder being divided between France, Australia, Italy and Spain.

It will be clear from the foregoing that the centre of gravity of the world's jute industry does not lie far from the city of Calcutta. The natural tendency to manufacture as closely as possible to the

source of the raw material aided largely by circumstances created by the war such as increased freights, etc., is bringing the centre of gravity closer still. This will be clear when it is realised that the consumption of jute in Indian mills is now more nearly two-thirds of the total crop than one half as formerly, giving employment in 1918 to 270,000 persons engaged in handling the raw material and in some 80 mills equipped with over 800,000 spindles and some 40,000 looms. This represents a truly remarkable development when one remembers that the first spinning mill was put down in India as recently as 1855 and the first weaving shed in 1859 some 20 years after the manufacture of jute had its first beginnings as a machine industry in Dundee.

Deccan hemp or Bimlipatam jute as it is sometimes called is a plant similar to jute and is grown in Madras and Bombay. About half of the crop of this plant, which before the war did not exceed 400,000 bales per annum, is exported, the remainder being manufactured in three Madras mills almost wholly for Indian consumption.

Jute, Preparatory Processes.

Jute is a bast fibre and as is the case with all vegetable fibres obtained from the stems as distinct from the leaves of plants it is found on the outside of the stalk of the plant and attached to it by a gummy substance. It is usually sown in the months of March, April and May, reaches a height of from 10 to 12 feet and is cut, not pulled as in the case of the flax plant, before it reaches maturity in the months of July, August and September and in some cases, in October. The plant is placed when cut in running water or in retting ponds for some 10 to 12 days or longer. When the process of retting is complete the fibre is easily separated from the woody stalks by hand or by treatment with a mallet. Power is not employed for the cutting of jute though it is possible that experiments now being carried out with a view to providing a suitable machine for pulling flax may, if successful, have a bearing on the cutting of the jute plant.

The fibre after retting and separation from the stem of the plant is made up loose or in bales and despatched to Calcutta to the mills or to the press houses for re-baling for export purposes. Loose jute is made up either in drums or in what are known as "kutchha" bales weighing, if hand pressed, 1½ maunds, and if power pressed, 3½ or 4 maunds each; sometimes for local transport and always for export, it is made up in power pressed "pakka" bales of 10-2/5ths cubic feet capacity and weighing 400 lbs.

Jute, Manufacturing Processes.

The jute as received at the factory, is stored in a warehouse from which it is taken to the jute opener or crusher.

Opener or Crusher.—This machine breaks up the material of the bales, jute from a number of which is fed on to it at once and also gives the jute a preliminary softening. The machine is usually run from 115 to 120 r.p.m. and requires some 3 to 4 horse-power to drive. After the jute has passed through the opener it is made up in "streaks" of a uniform weight by the batchers who also remove any inferior fibres and these "streaks" are fed on to a machine called a softener.

Softener.—The softener is provided with a series of rollers which may be fluted or straight and during its passage through this machine warm water and oil are fed on to the fibre. Where hand batching is employed, the water and oil are added to the jute after its passage through the softener. The object of the process is to soften the fibre and improve its spinning qualities. Softeners vary in size depending on the number of pairs of rollers usually from 31 to 79 and the speeds recommended by the different makers vary from 135 to 145 r.p.m.

For estimating purposes from 3½ to 7 pairs of rollers per B.H.P. may be allowed, softeners with a small number of rollers taking a proportionately larger power than those with a large number of rollers. It should be noted that these machines may occasionally be heavily overloaded for a short period to as much as 60% in excess of the normal load. A jute softener has by law to be provided with an automatic knock-off motion which comes into operation if the operative is accidentally dragged forward by the feed. After passage through the softeners the fibre is stacked for over 24 hours with a view to the more thorough distribution of the oil and water throughout the mass; the fibres are then usually cut by hand and transferred to the preparing department where the resulting "streaks" are placed on the first machine in that department, viz., the breaker card.

BREAKER CARD.—This machine does for the coarser long vegetable fibres like jute and for tow, etc., what is done by a more expensive heckling and spread board or gill box treatment for the finer long vegetable fibres, i.e., it converts them into a long smooth band known as the "sliver." These machines, the cylinders of which are generally 4 feet in diameter with a 6 ft. face and occasionally 5 ft. in diameter with a 6 ft. face, may run at from 175 to 210 r.p.m., the horse-power varying from 4½ to 6 B.H.P. The starting torque is high and the load is not always evenly distributed among the machines installed.

In order that uniform yarn may be produced the feed to the machines has to be controlled at some stage in the process of manufacture. This is usually done by weighing the feed to the breaker card and distributing it over a measured length of feed lattice. It may, however, also be done after the sliver has left the Breaker card by passing it into a balling or lap machine.

BALLING OR LAP MACHINE.—This machine takes a number of slivers from the breaker card and converts them into "laps" of uniform weight for a given length. It is usually run at 300 r.p.m. and takes approximately 1 H.P. to drive. The sliver from the breaker card, or if a balling machine is employed, the "lap" from this machine is placed on the feed of an intermediate or a finisher card. The designs of the breaker, intermediate and finisher cards are generally similar and the first and last are as a rule alone employed in Bengal while on the other hand intermediate cards are common in Dundee.

FINISHER CARD.—The finisher card carries on the work from the breaker card or the intermediate card as the case may be, cleans the fibres and renders them more parallel. The speed of the finisher varies from 160 to 220 r.p.m. and the power from 3-4 H.P., being less than that required by the breaker cards. The sliver from the finisher card is also dispatched in a sliver can and from this can is fed to the first drawing frame.

FIRST DRAWING FRAME.—Several slivers from the finisher cards are combined and pass through the drawing frame together, being elongated, rendered more parallel, and converted into a sliver more regular in weight per unit length. Drawing frames are designed on different principles, the more common being "push bar" and "spiral" drawing, the former largely used for first drawing frames and the latter for second drawing frames. The speeds of these machines vary from 160 to 300 r.p.m., the push bar drawing frames usually running at a higher speed than the spiral frames. The horse-power depends on the number of delivery heads, which are found to vary from 2 to 8, there being usually from 4 to 8 slivers per head. Two heads per horse-power is a safe figure on which to estimate. "Spiral" drawing requires less power than push bar drawing. From the first drawing the sliver is transferred to the second drawing frame.

SECOND DRAWING MACHINE.—The particulars of this machine are generally as for the first drawing, several slivers being usually run into one as in the case of the first drawing. From the second drawing frame the sliver may be passed on to a third drawing frame of similar design or as is more usual in Bengal to the roving frame, which is the last machine in the preparing department.

ROVING FRAME.—In this machine a slight twist is, for the first time, given to the sliver in order to permit it to be further drawn out. The roving frame consists of spindles and flyers placed in front of a set of drawing rollers. The speeds of roving frames vary from 200 to 215 r.p.m. the spindle speeds being generally three times this. The number of spindles per frame varies from 40 to 72, and 12 to 16 spindles may be taken per horse-power. From the roving frame the product is passed on bobbins to the spinning frames.

SPINNING FRAME.—The dry spinning process is almost invariably employed in jute, wet spinning being reserved for the finer classes of long vegetable fibre such as flax, etc. The frames employed are invariably flyer frames, the flyers of which are positively driven, the bobbins running loose under the control of a drag weight. The traverse of the bobbins varies from 3 to 5 inches, the corresponding spindle speeds varying from 4,000 to 2,000 r.p.m. The spindles are driven by tapes passing round a cylinder and driving on to wharves on the spindles. The machines usually have two sides the number of spindles per side varying from 64 to 80. The tin drum speeds vary from 400 to 570 r.p.m. There is a variation in the power taken during the traverse of the bobbin, involving a variation

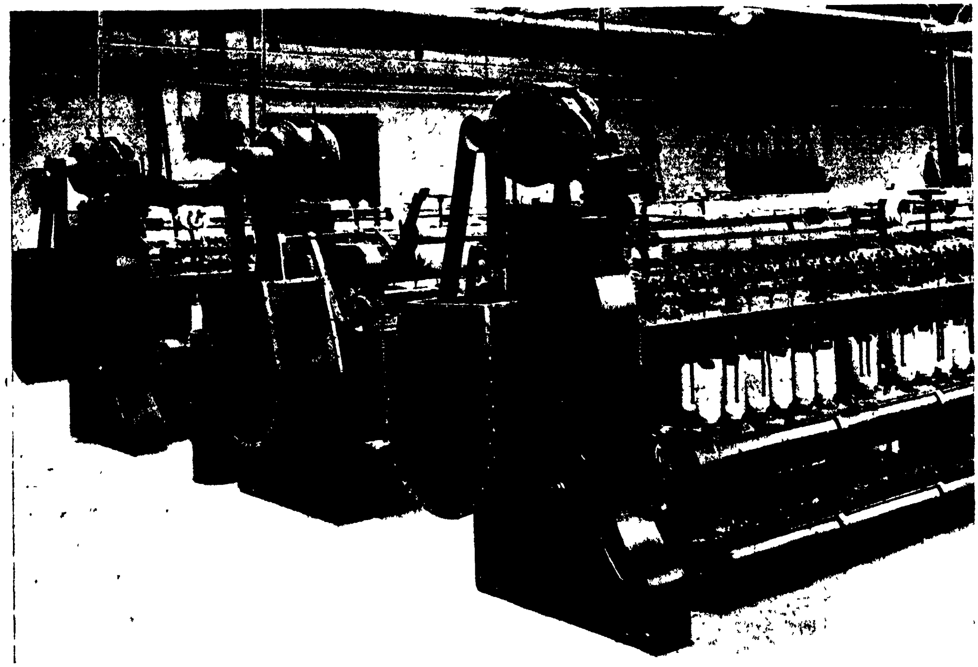

FIG. 4.—Individual Electric Drive for Roving or Spinning Frames.

FIG. 5.—Individual Electric Drive of Dressing Machines (Dundee).

between the top and the bottom positions of some $12\frac{1}{2}$ %, the power being greatest when the carriage is at the top. This is due to the unmechanical nature of the drive provided by the tin rollers. This variation is reduced to some $7\frac{1}{2}$% by a patent auxiliary tin roller drive that has recently been introduced, which has also had a remarkable effect on the power consumption. The following test figures may be of interest:—two frames with the old single cylinder drive gave respectively 12·2 and 11·7 spindles per B.H.P., a frame of the same dimensions and to the same particulars but with the auxiliary cylinder drive and running at a slightly higher speed, but it is worthy of note at a slightly lower tin drum speed thus showing less slip, gave 16·5 spindles to the horse power, a remarkable improvement in efficiency. The makers claim rather a higher saving than this but these figures were actually obtained in independent tests. This drive, either in the patented form or some variation of this, is in fairly general use.

We have now jute yarn which depending on the class of fibre selected and on the adjustment of the preparing and spinning machinery described, is suitable either for "warp" as the threads which run through the length of a woven fabric are collectively termed, or for the "weft" which "crossing and interlacing" with the warp makes up a jute or part jute fabric. Whether intended for warp or for weft, if the yarn when it leaves the spinning frame has to be sent to a distance or sold it is made up into "hanks" on a reeling or hanking machine. Hanks are made up of a uniform weight depending on the counts of the yarn, and after leaving the hanking machine are sized and made up into bundles in a hand operated bundling press. The hanking reel is sometimes driven by hand but is more usually power driven. The *Power Hanking Machine* is usually double sided and capable of making from 12 to 24 per hanks per side. Such a machine running at 75 r.p.m. and having 20 hanks per side, was found to take ·6 H.P. When the thread is intended for warp yarn it is generally wound from the spinning bobbins into rolls or "cheeses" the contents of a number of bobbins being absorbed in one roll. This is also done when hank yarns have to be twisted, sized or otherwise treated. The operation is carried out on a *Roll Winding Machine*. This machine runs at about 240 to 400 r.p.m. and is usually double sided with from 20 to 70 spindles per side. A usual power allowance is 24 spindles to the horse power.

Weft yard is prepared for the loom in two alternative ways, viz., by being wound as cops generally from $1\frac{1}{4}''$ to $1\frac{7}{8}''$ in diameter and 8″ x 12″ long or by being wound on pirns. Cops are placed direct in the loom shuttle, the thread being unwound from the inside and are now almost universal in jute weaving. A *Cop Winding Machine* is usually double sided with 45 to 60 spindles per side and runs at from 250 to 440 r.p.m. The spindle speed for 12″ x 2″ cops is about 800 r.p.m. and for 10″ x 1·6″ cops about 1,000 r.p.m. and the number of spindles to the horse power varies from 16 for the larger bobbins to 20 for the smaller. A *Pirn Winding Machine* takes about the same power but runs about 180 r.p.m.

We have now to deal with the warp rolls or cheeses already referred to and which have to be converted into the long band of threads known as "warp." For use in the loom also the warp has to be beamed, viz., wound on to the weaver's beam or beams which are found at the back of every loom.

In most cases and particularly for the better class fabrics the warp threads before being wound on the weaver's beam are sized or "dressed" as it is termed. Dressing has many advantages, it improves production in the spinning department as less twist is needed for dressed yarn; it reduces waste and facilitates weaving. Dressing is now almost universal in the jute industry, the use of the dry, or "green" warps being very limited.

There are many methods employed for preparing warp yarn for the loom. Four distinct methods each with its own manufacturing variants are to be found. The author is, however, only concerned with noticing the machines in common use so that the problem of driving may be more readily considered and will therefore confine himself to the more general systems of jute warping and beaming.

In all systems a number of warp rolls or in some cases where roll winding is not employed, bobbins direct from the spinning frames are placed in a creel or bank generally of V shape and capable of carrying anything from 40 to 500 spindles depending on the system adopted. From this bank or creel the yarn if it is not to be dressed passes to a *Beaming Machine*.

A dry yarn beaming machine may be single or double, viz., it may be fed from one creel or from two creels one at each end; it may also be with or without drawing rollers. The speed of these machines is about 80 r.p.m. and the H.P. from 1½ to 2 B.H.P.

Where jute warps are dressed the complete operation of dressing, warping and beaming is carried out in a single machine called a *Dressing Machine.* This machine is provided with steam heated cylinders, and has either one set of two cylinders, two sets of two cylinders, one set of three cylinders, or two sets of three cylinders. The machines usually run at about 450 r.p.m. and the more common widths are 60″ and 72″, the power varying from 3-3½ B.H.P.

Where warps are manufactured for sale a new method of warping is finding application, particularly in Dundee, viz., link or chain warping. The *Linking Machine* so called, which was introduced from the cotton trade, consists of the usual bank or creel, a leasing apparatus, a measuring machine and the linking machine proper. The linking and the measuring machine alone are power driven. They are mechanically coupled together and driven as one machine absorbing about 1·5 B.H.P. In some machines two warps may be linked at once or one only may be dealt with.

Instead of converting the warp into a chain by the process just described, it may be passed into a machine called a *Ball Warping Machine,* which delivers the warp wound on a series of rollers not unlike "cheeses" but larger. This machine takes approximately ·5 B.H.P. to drive. Whether prepared in the linking or in the ball warping machine, the warp has to be put through a beaming machine, in some cases after being dressed and in other cases in a "green" condition.

(*To be continued.*)

OBITUARY.

Sir Richard Vassar Vassar-Smith, Bt., D.L.—Sir Richard Vassar-Smith, Chairman of Lloyds Bank, died at his London residence, 16, St. James's Street, on August 2nd. A son of Mr. Richard Tew Smith, of Wotton, Gloucester, he was educated at the local College School, and began his successful business career in his father's firm of agents and carriers to the Great Western Railway, becoming head of the concern at the age of twenty-seven. He assumed the additional name of Vassar by Royal Licence. When, in 1889, Lloyds Bank absorbed the Worcester City and County Bank, of which he was a director, he joined the board of the former and was appointed to the chairmanship in 1910. The numerous public positions he filled at different times included those of President and Chairman of the Council of the Bankers' Institute, Chairman of the Committee of the London Bankers' Clearing House and Chairman of the Central Association of Bankers. Throughout his busy life he took an active interest in the affairs of his native county, the Gloucestershire Territorial Association, for instance, owing much to his support He was also a member of the Council of Cheltenham College, Chairman of Council, Cheltenham Ladies' College, and Chairman of the Council of St. Hilda's Colleges, Oxford and Cheltenham. His baronetcy, conferred in 1917, was a well-deserved recognition of the valuable services he rendered to the country, especially in connexion with the great banking institution he so ably controlled. Elected a Fellow of the Royal Society of Arts in 1919, he was a member of the Council for twelve months.

Richard William Crowther, F.S.A., J.P.—By the death, on July 21st, in his seventy-fourth year, of Mr. R. W. Crowther, Chairman of Messrs Sewell & Crowther, Ltd., the Society loses an old and respected member; he was elected as long ago as 1881 Mr Crowther took an active and useful part in the public affairs of Stoke Newington, where he resided, and when Alderman Sir John Baddeley became Lord Mayor of London, succeeded him as Chairman of the Stoke Newington Justices

MALAYA'S NEW POTTERY INDUSTRY.

Because it represents an entirely new industry to Malaya, the formal opening of the pottery works at Gopeng was made the occasion of somewhat elaborate ceremonies. The plant, which is situated about 16 miles from Ipoh, is equipped to handle all the processes from refining the crude clay to the decoration of the completed piece.

According to a report by the United States Consul at Penang, casting and jolleying are the processes used, permitting a comparatively large output with labour that is not yet thoroughly trained. Teapots, jugs, ewers, and basins are already being turned out, notwithstanding that a few weeks ago the Malay girls employed in the casting room had never seen a pottery. As the available labour becomes more skilled the production of porcelain ware in bulk is contemplated.

All the materials required for pottery making are found within 3 miles of the works. Besides supplying its own clay requirements, the company ships china clay to cotton mills in Bombay and paper mills in Calcutta. The barrels for packing the product, it may be mentioned, are made at the works.

The establishment of this new industry in Malaya has aroused widespread interest.

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FRIDAY, AUGUST 18, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

INDIAN SECTION COMMITTEE.

Lord Askwith, K.C.B., K.C., D.C.L. (Chairman of the Council).
Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I. (Chairman of the Committee).
Sir Charles H. Armstrong.
Sir Arundel T. Arundel, K.C.S.I.
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Thomas McMorran.
Sir William S. Meyer, G.C.I.E., K.C.S.I.
Sir John Ontario Miller, K.C.S.I.,
Brigadier-General Lord Montagu of Beaulieu, K.C.I.E., C.S.I., V.D.
F. Noyce, I.C.S., Indian Trade Commissioner.
Right Hon. Sir Joseph West Ridgeway, G.C.B., G.C.M.G., K.C.S.I.
N. C. Sen, O.B.E.
Colonel Sir Richard C. Temple, Bt., C.B., C.I.E.
Carmichael Thomas.
J. A. Voelcker, M.A., Ph.D., F.I.C.
N. N. Wadia, C.I.E.
Sir Frank Warner, K.B.E.
Colonel Sir Charles Edward Yate, Bt., C.S.I., C.M.G., M.P.
S. Digby, C.I.E. (Secretary.)

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, 26TH APRIL, 1922.

SIR JOHN F. C. SNELL, M.Inst.C.E., Chairman of the Electricity Commissioners, in the chair.

The paper read was:—

THE USE AND ADVANTAGES OF ELECTRIC POWER IN THE FACTORY, AS ILLUSTRATED BY ITS APPLICATION TO THE JUTE INDUSTRY.

By J. F. CROWLEY, D.Sc., B.A., M.I.E.E.

(*Continued from page* 676.)

THE LOOM.—The next operation with which we have to deal is that of weaving which is carried out in a loom which may vary in reed space—roughly corresponding to the maximum width of cloth—from 30″ to 156″. As a rule jute looms are of the plainest description, dobbies being very seldom fitted and jacquards being used only for the making of jute carpets and similar goods, the manufacture of which is, however, a separate industry.

The jute loom has certain special features which distinguish it from a power point of view from other looms. In the first place the crank-shaft is set unusually far back from the front of the loom to allow of a larger movement of the "lay" to accommodate a large shuttle and to provide extra space for the harness.

A jute loom also requires a high starting torque usually 2-2¼ times normal torque, and has a particularly irregular power cycle as may be seen from the torque curve illustrated in Fig. 6. This curve which the author

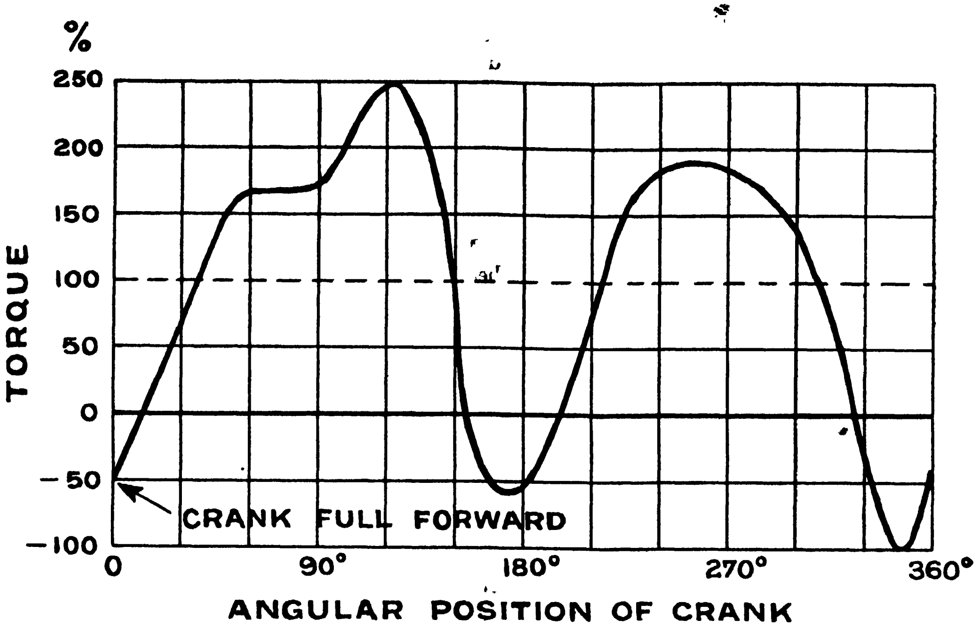


FIG. 6.—Cyclic Variation in Torque of a Jute Loom

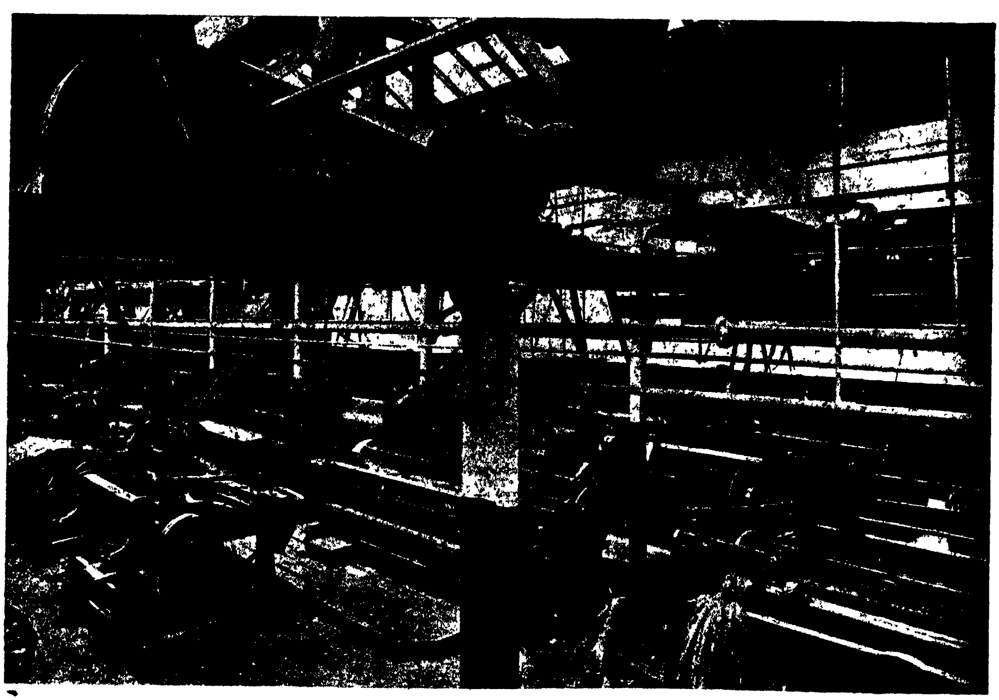


FIG. 7.—Group Electric Drive with Chain Transmission (Dundee).

believes to be the first such curve published, was taken on a loom driven by an individual electric motor and may be taken as representing the cyclic variation in torque of a standard jute loom. It will be noted that the loom is actually returning energy to the driving system during part of the cycle. The speeds of looms vary from 90 picks per minute to 180 picks per minute, depending on the reed space. The average power taken by a group of looms, allowing the usual load factor for weaving sheds varies from ·5 B.H.P. to 2 B.H.P. per loom. The load factor or weaving efficiency of a jute shed varies from 45% to, in the very best cases, slightly over 70%, depending on the class of material woven, the type of operative, etc.

If the material woven is not of a sufficiently fine quality to require mangling, it is delivered to a *Damping Machine*. These machines generally run at 140 r.p.m. and take approximately 1 to 1·5 B.H.P. to drive. After the cloth has been damped it is passed on to a calendering machine.

CALENDER.—This machine consists of a number of pairs of rollers, the centre roller being heated by steam and varying degrees of pressure are maintained on the rollers by means of weights on a lever system. The cloth may be passed singly between the rollers when what is known as a "flat" finish is imported to it or it may be wound on to one of the rollers for a "chest" finish. The first treatment is the more usual and for that treatment the calender revolves continuously in the one direction; for a "chest" finish on the other hand, the calender reverses its direction of rotation periodically.

All calenders, except those arranged for individual electric drive, are provided with a straight belt and a cross belt drive from the line shaft and a clutch that can be engaged with either of the two driven belt pulleys to enable the direction of rotation to be reversed. A reversing motion is required by law to be fitted to all jute calenders. In the front of the calender is a small winding off roller which is usually provided with an auxiliary drive. The usual sizes of jute calender are 96″ and 132″, the horse-powers generally allowed being 15 B.H.P. and 20 B.H.P. respectively. It should be noted that these machines have an abnormally heavy starting torque.

If a high-class finish is required, the material is treated in a mangle instead of in a calender; in this case before being damped the material is passed through a *Cropping Machine*, which is generally 72″ or 96″ in width and takes from 5 to 6 B.H.P. to drive; depending on the width and on the number of spirals on the machine. After being cropped and damped the material is passed on to the mangle.

MANGLE.—A mangle is a much larger and heavier machine than a calender, and works with a much higher pressure between the rollers, usually varying from 40 to 120 tons, and produced hydraulically. The method of operation consists of winding the cloth to be mangled completely on to one roller, the cloth being pressed between this roller and another. The operation of the machine is reversed about every 6½ seconds, the cycle of operation being as given in Fig. 11. The complete operation of mangling requires about 11 minutes, but varies somewhat with the material. The arrangement for reversing the mangle is mechanical and consists of clutches of the expanding crown type, put in and out of operation by an auxiliary mechanism worked from the line shaft; the usual widths of mangles are as in the case of calenders 96″ and 132″. The horse-powers usually employed for individual driving are 55 B.H.P. for the 96″ and 70 B.H.P. for the 132″ size.

The length of the cloth produced on the loom is measured by a *Measuring Machine*, which takes from 1 to 1·5 B.H.P. to drive. It can be "crisped" or folded double on a *Crisping Machine*, which takes about the same power as the measuring machine and made into rolls by a *Rolling Machine or Calenderoy*, which also absorbs about the same power. The measuring, crisping and rolling may be carried out in one operation, in a combined machine when the power required is about double that for one of the single machines.

If the material is to be made into sacks or bags, it is cut to the correct size in a *Sack Cutter*, which may be hand or power driven and if the latter absorbs from 1 to 1·5 B.H.P. The sewing of these sacks is done on a strong type of *Sewing Machine*, which takes from ·12 to ·25 B.H.P., and *Hemming Machines* also are employed, taking about ·12 B.H.P.

Among other machines that may have to be driven are the *Root Opener* which takes about 8 H.P.; the *Waste Cleaner* or *Dust Shaker*, from 1·5 to 3 H.P.; the *Teaser* from 4 to 4·5 H.P.; the *Mixer*, about 5 H.P.; and

Fig. 8.—Individual Electric Drive in Weaving Shed (Calcutta).

Fig. 9.—Individual Electric Drive of Damping Machine (Dundee).

the *Twister*, usually of the flyer type and largely used for doubling yarns. With dry spun yarns like jute, the twisting may be done from the spinning bobbin or the yarn may first be wound upon longer bobbins or spools. The bobbins range from 2½″ diameter, 4″ traverse, to 6″ diameter, 10″ traverse, the pitch from 4″ to 9″ and the spindle speeds from 1,100 r.p.m. to 2,500 r.p.m. The pulley speeds are generally slightly less than those of the corresponding spinning frames. A frame of 4″ pitch would require about 1 H.P. for every 14 spindles and a frame of 5″ pitch 1 H.P. for every 12 spindles.

Provision has also to be made for the drawing of the *Hydraulic Press Pump*. This generally consists of 8 rams, and takes from 45 to 50 H.P. to drive. The cyclic variation in torque is high when the pump is operating at high pressure since in this case it is usual to employ four only of the eight plungers. When operating at low pressure on the other hand the torque variation is not considerable.

As a rough guide to the total power requirements of a complete jute mill and its associated factory—the name mill it should be mentioned, is usually applied to the preparing and spinning departments, and factory to the weaving sheds—it may be said that for the preparing, spinning, weaving and finishing departments, from 3¼ to 3¾ H.P. per loom has to be provided depending on the class of goods handled and on the degree of finish imparted.

It will be found that the power taken by individual machines in any department of a mill varies with the quality of the fibre employed, the speed at which the machines are driven and with the manufacturing efficiency of the department, which determines the number of machines running at a given instant, and it will also be found that the machines of different makers require different powers to drive; subject to these qualifications the figures given furnish a fair indication of the usual power requirements. While based in most cases on actual tests they should be used only as a general guide and in no case should powers be based on them without due regard to the factors mentioned.

It need scarcely be said also that the particulars of the textile processes are given purely for the guidance of engineers, and are in no sense intended to be taken as having any authority from a textile stand-point.

THE DISTRIBUTION OF POWER.

We have so far considered the sources of power available to the manufacturer, the principles that should govern its application and the essential elements of the jute industry, from the point of view of the power engineer. We have now to consider the most suitable method of distributing the energy from the prime mover, through the factory, until it finds its application at the shaft of the driven machine. This distribution system may comprise one or many links, and these links may be wholly mechanical, electrical and mechanical, or wholly electrical.

Mechanical Distribution.

In the early days of factory driving in Great Britain, it was usual to find a Boulton & Watt engine connected by spur gearing to line shafting, and this, in turn, driving the machines by means of leather belts, the additional shafting being driven by further gears, either plain or bevel. Owing to the irregular character of the drive produced, the power lost in transmission, and to the difficulty of suitably connecting various shafts—frequently at different angles to each other—together, this system is almost wholly replaced in modern mills by a rope transmission system from the flywheel of the engine. If such a system is carefully thought out in a factory suitably designed, it is probably the best mechanical distribution system for heavy powers. An example of a weaving shed drive comprising rope and bevel gears, is given in Fig. 1, where ropes from the flywheel of the engine drive the second motion shaft, which, in turn, drives the cross shafts through bevel gears. In general, a prime mover of slow speed and low output is connected to the line shafting by ropes, chains or belts of fabric or leather; and if of slow speed, but high output, by ropes or steel belts. Steel belts have been introduced on the Continent for heavy drives of a moderately slow speed, and appear to have given satisfaction. There has not, so far, been much experience in this country with them.

Where the prime mover is of high speed, as in the case of a turbine drive, if electrical transmission is not employed, it is usual to adopt a double helical self-contained single or double reduction gear connected through a coupling to the turbine shaft, for reducing the speed to one more suited to the ordinary transmission systems.

Fig. 10—Individual Electric Drive of Jute Calender (Dundee).

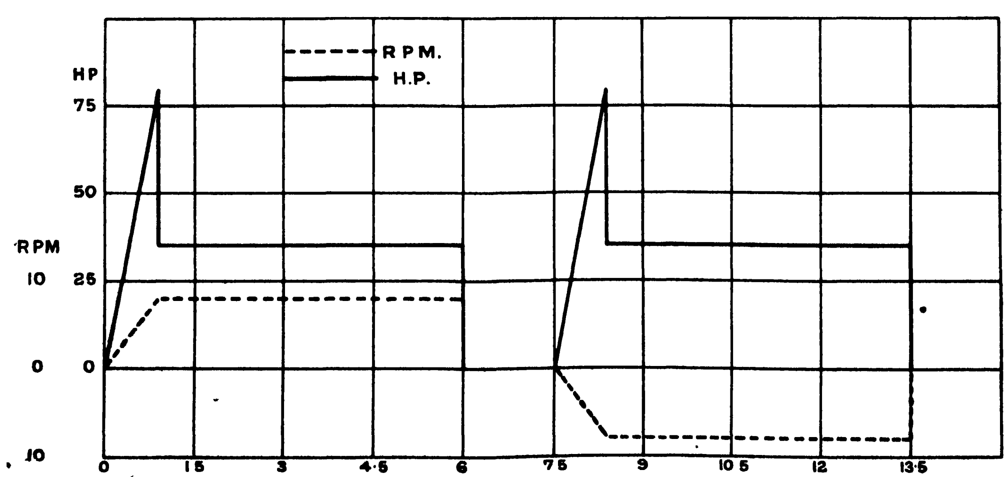


Fig. 11.—Type of Torque and Speed Curve of Jute Mangle.

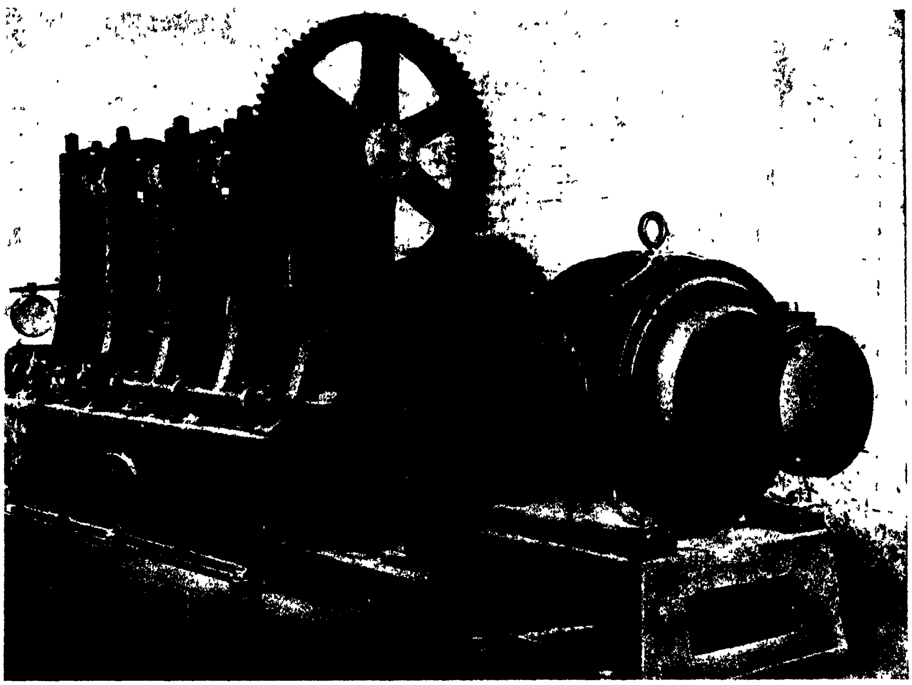


FIG 14.—Individual Electric Drive of Press Pump (Calcutta).

The slow speed shaft of such a gearing is then connected to the line shafting through ropes, chains or belts in the ordinary way. In India, where this drive has been adopted to a certain extent, it is not unusual to find the second motion shaft of the geared turbine connected through a flexible coupling to one of the heavier mill shafts, the remaining shafting only being driven through ropes. This system has the advantage of effecting a considerable saving in the power lost in transmission, in the case of the direct coupled shaft, but there is a distinct loss of flexibility as the turbine has, of necessity, to be lined up to the shaft, with which it has to be coupled, and this generally means placing it in an unsuitable position.

The whole of the power also is transmitted through the reduction gear, which is liable to be a source of weakness.

It is not intended to consider closely the merits of the different methods of mechanically distributing power, but the following points may be of interest. Belts, which form one of the earlier methods of drive, have still a definite function, particularly for the transmission of low powers. Indeed, through improvements introduced by manufacturers and others, their position has recently been strengthened. The development, principally on the Continent, of the jockey pulley drive has extended the field for belt drives, which are now designed to cope with short belt centres, and exceptionally high pulley ratios.

If due attention is given to layout, rope drives should give satisfaction. The minimum diameter of pulley round which the rope has to pass should not be less than thirty diameters, if a reasonable rope life is desired. Driving centres also should not be much less than 20 feet for the larger powers, and the angle of drive should not, if possible, exceed 45 degrees with the horizontal. The efficiency of rope drives is not high, but the drive is more flexible, and more steady than can be obtained from gearing.

Chain driving has come to be recognised as a standard method of driving for moderate powers at ratios below 6 or 7 to 1. The drive is positive, being akin to machine cut gearing in this respect. It is, however, flexible in application, needs less aligning to shafting than gearing, and is, in practice, of at least equally high efficiency.

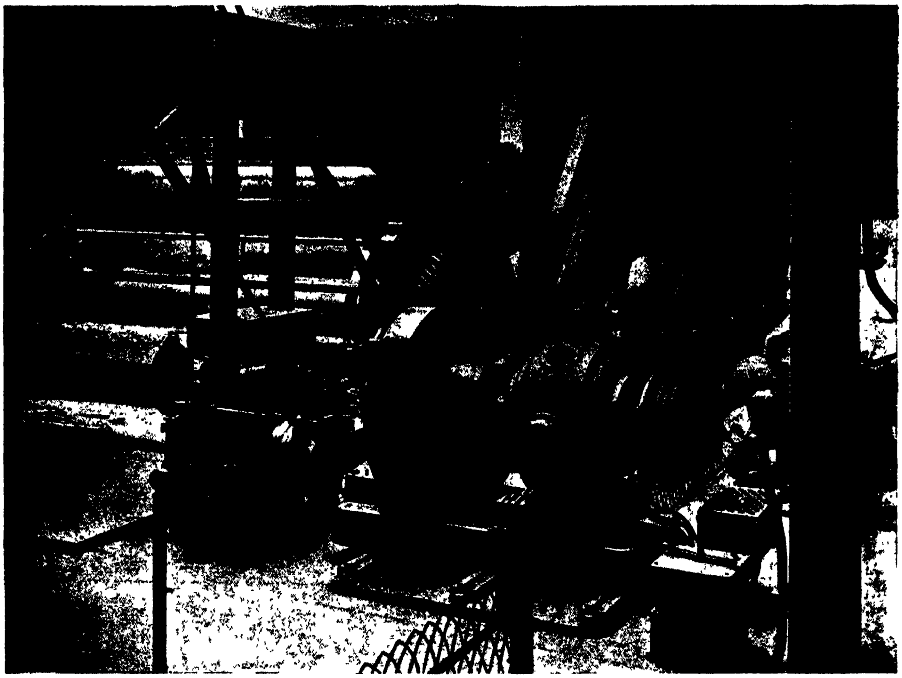


FIG 12.—Individual Electric Drive of Jute Mangle (Dundee).

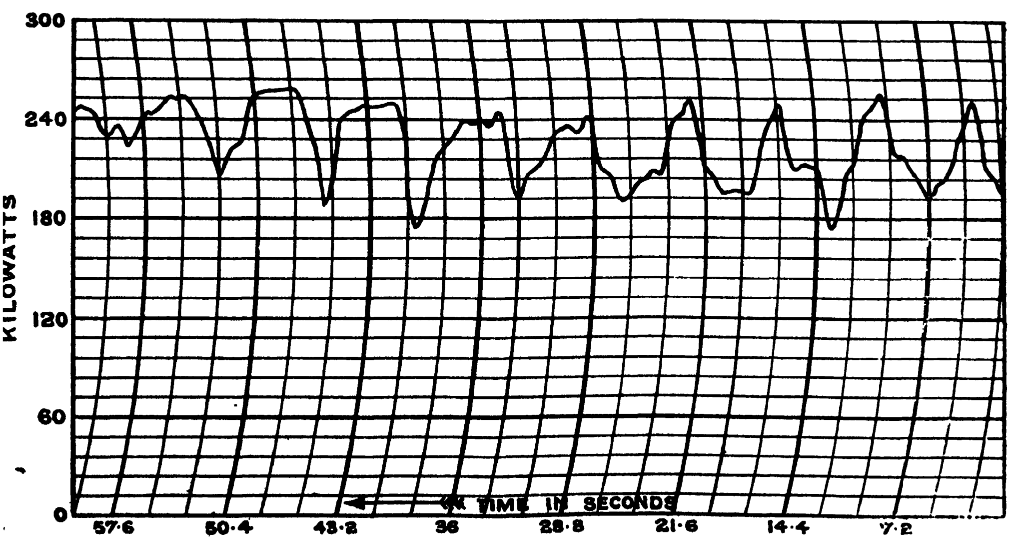


FIG. 13.—Power Record showing effect of Mangle Load.

Chain driving is particularly useful where it is found desirable to drive shafts from the centre with a view to keeping cyclic irregularity in speed within proper limits. Electric motors and chain transmission enable this to be done very satisfactorily, as may be seen from Fig. 7, which illustrates a drive of this kind.

Electrical Distribution.

When electrical distribution is employed, a single large electric motor may be installed to drive the whole of a factory, occupying then the position that would, in a mechanical system, be occupied by the turbine, reciprocating engine or other prime mover. Instead of employing one large motor, a number of small motors can be installed to drive each machine on the principle known as the "Individual Electric Drive." The individual motors may be direct coupled to the machines, or drive through a simple transmission link as, for instance, a belt, chain or gear. Between these two systems lie the various groupings of shafting, which are designated "Group Electric Driving in Large Units," or "Group Electric Driving in Small Units," depending on whether the motors are large and drive a number of shafts, or small and driving only small groups of shafts. Just as there is no golden rule as to what transmission system should be employed, so is there no golden rule as to the system of electric driving that should be adopted. Each case has to be carefully considered on its merits, and in the light of experience gained in a similar class of work. Certain guiding considerations can, however, be laid down. In general, the installation of a single large motor, involving as it does the retention of a complicated mechanical power transmission system with its many defects, brings few, if any, of the advantages of electrical driving, and is not to be recommended, nor, indeed, is the unconsidered adoption of individual electric driving. While, undoubtedly, the ideal drive, where motors exist, as they now do in almost every case, suited to the work to which it is proposed to set them, individual drive is, in many cases, more costly than group drive. Where this is the case, its application should be confined to machines where it can be shown that its installation has a commercial advantage.

The dividing of the shafting into large or small groups is governed, to a certain extent, by the desire to reduce the lengths of line shafting, in order to reduce speed variation or friction losses, and also by the nature of the processes carried on, which in some cases, require certain departments to be driven independently, on account of overtime and of separate power costing.

The principle of providing separately controlled drives for each department is not difficult to apply in a jute factory, particularly in India, where almost all the mills are on the shed principle, and the raw material from the godowns is, as a rule, arranged to enter at one end of the building, passing on through the successive departments until it reaches the baling-presses as a finished article.

Each department is generally driven by one or more line shafts, running parallel to each other across the full width of the building, there being some eight such shafts in a 500 loom mill, and a similar number of shafts, but of much less power, in the weaving shed. In a mechanically driven mill these shafts are usually connected by ropes, running in a rope race, to the engine. In arranging for the conversion of this type of mill, to electric drive, motors may be placed in the rope alley-way, and connected by belts to each separate shaft, as in Fig 15, or by ropes as in Fig 16, which illustrate two such conversions. Weaving shed shafts, which generally run at about 180 r.p.m., are best driven by chain, one motor being placed between two shafts and driving both, or, as in Fig. 7, one shaft only.

Electric motors may be placed at the ends of the shafts they have to drive, or in the middle. Placing them in the middle has the important advantage that cyclic variations in speed are very much reduced, but, on the other hand, the overhead view is interfered with, and separate steel platforms have to be provided to carry the motors. There is one important exception to this. The design of many Indian jute mills is such that it is possible and practicable, to place motors over the centres of the shafts they have to drive, connecting them to these shafts by chains, the motors themselves being suitably housed in a simple superstructure raised on the flat shed roof. If placed at the ends, the motors are in the clean atmosphere of the alley-way, but the speed irregularity of the shafts may be excessive, particularly if the shafts exceed, say 300 feet in length, as they do in many Calcutta mills where at least one shaft 700 feet long is installed. In general, it is

FIG. 15.—Group Electric Drive with Belt Transmission (Calcutta).

desirable to drive weaving shed shafts which are light, subject to considerable variations in torque, and require only a small power from the middle, and the heavier shafts from the end, or if of exceptional length, from both ends. The modern method of driving spinning and preparing rooms is to run the shafts at 485 r.p.m. (softener and card shafts being sometimes run at a lower speed) and couple the motors direct through flexible couplings. An example of such a drive is given in Fig. 17, which shows a modern drive, the motors being placed on masonry piers connected together by a platform, and the motor starters on the ground. Another example of a recent installation is illustrated in Fig. 18, which shows in the foreground the larger motors for the preparing and spinning rooms direct coupled to their respective shafts, and in the background smaller motors driving the weaving shed shafts through chains.

Weaving shed shafts should not, under any circumstances, be increased in speed beyond that speed which gives approximately a one to one pulley ratio. An attempt was made a short time ago, to increase the speeds of weaving shed shafts to 368 r.p.m., with results that might have been foretold, when it is remembered that a jute loom takes over twice normal torque at the start, is frequently starting and stopping, and has besides a very irregular torque curve, as was seen from Fig. 6. In this case the motors had to be removed, and the shafting reduced to the normal speed.

If a machine runs intermittently or requires complicated shafting to drive it

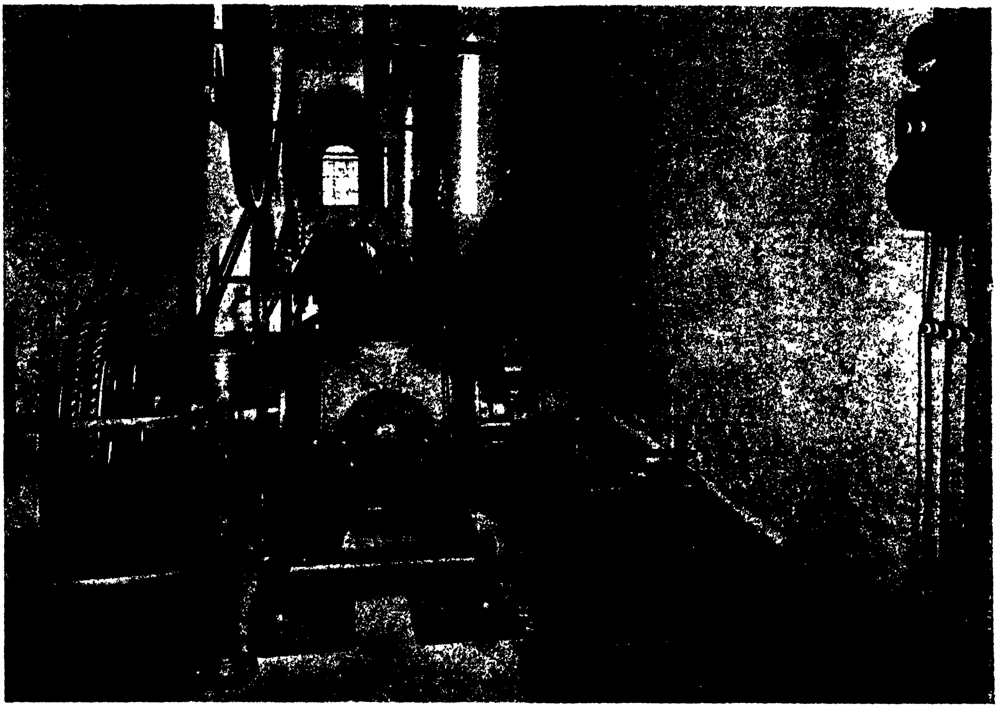


FIG. 16.—Group Electric Drive with Rope Transmission (Calcutta).

FIG. 17.—Group Electric Drive with Direct Coupled Motors (Calcutta).

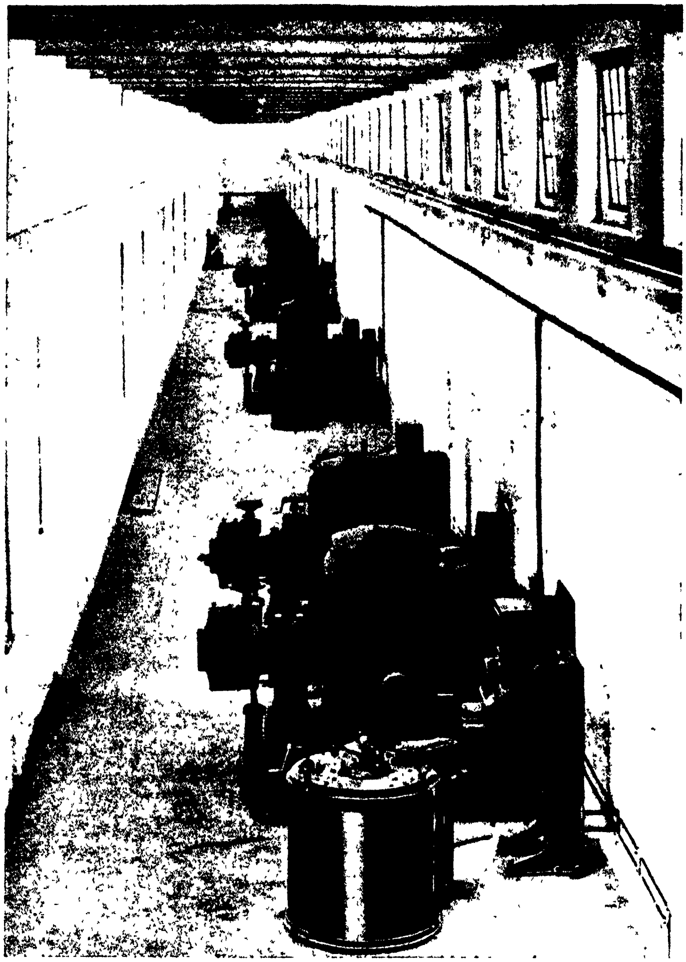


FIG. 18.—Motor Alleyway of a Modern Jute Mill (Calcutta).

it is probable that it will be desirable to drive it individually. If, too, an exceptionally steady speed is required, as is the case, for instance, with spinning frames and automatic looms, individual drive will almost certainly prove most suitable. It is further, eminently desirable that all irregularly running machines, that is, machines which "start" or "stop" frequently, or machines, on the other hand, that have an irregular torque, should not be allowed to interfere with the steady running of other machines on the same line shafting. These should, therefore, be driven by individual motors.

Reference to Fig. 13 will show the serious effect on the power load of a line shaft in a jute mill of the irregular torque of a jute mangle driven from the shaft, and no further proof should be needed of the importance of removing such irregular running machines from line shafting which has to drive machines that need a steady speed. A similar case would be that of spinning mules in a cotton mill. Here it is clearly desirable that the mules should be separately driven, and not allowed to interfere with the smooth running of other machines. *Softeners* should be individually driven. They furnish an irregular load, and a long line of shafting, idle for the greater part of its length, is required to drive them on the group system. Spinning frames lend themselves admirably

to individual drive. An example of a drive suitable for roving, slubbing and spinning frames is given in Fig. 4, the illustration being from an installation put down by the author in an asbestos factory. This, it may be added, is the only illustration given in the paper, which is not taken from a jute factory. Direct coupled motors can be used for spinning frames where the speed of the tin drums can be increased to permit of a motor of standard speed being used. In this case, however, the motor must be of special design, or the drive so arranged as not to give too abrupt a start, which is liable to cause yarn breakage in frames of the "flyer" type.

For *Looms* the individual electric drive is ideal, and its application for this purpose has been exceptionally rapid. It will be possible to deal with only a few of the leading features of this drive, an example of which, from a modern Indian mill, is given in Fig. 8. Fully enclosed three-phase motors capable of giving a high starting torque, with a remarkably high efficiency over a wide range of load and arranged to be suitable for belt or single reduction gear drive are employed. In the case of the belt drive, springs are introduced into the motor mounting so as to give the flexibility needed to deal with shafts which are sometimes out of truth. When gear drive is desirable, as in the case of low speeds, and for delicate materials, a slipping coupling is introduced, which is so adjusted as not to slip at start, but only on the abnormal overload produced by what is known to the textile manufacturer as a "knock-off."

The most remarkable feature of individual loom drive is the increase in production that results from its use. Through the courtesy of the Agents of a large Indian mill,* where he installed this drive, the author has received permission to publish comparative tests taken over a period of twelve months between some hundreds of looms running on "Hessians" and "Sackings," and driven mechanically by a modern reciprocating engine and a similar number of looms driven by individual electric motors. The individually driven Hessian looms showed an increase in production of 13 per cent., and the Sacking looms an increase of 8 per cent. over their mechanically driven neighbours. In the Mill Engineer's report, it is stated that the coal consumption with the steam drive is very considerably in excess of that with the electrical drive, that there is a very considerable saving in regard to labour and oil, and what is of considerable importance, in mechanical upkeep on the looms, and he concludes: "It is possible to build a mill and drive it electrically, paying for it by the amount saved in running cost together with the increased production, in a period of from three to four years, or even less, if an exceptionally prosperous season and market favour one."

* Wellington Jute Mills, Calcutta.

Individual electric drive should be applied to *Dressing Machines* (Fig. 8), and to *Damping Machines* (Fig. 9), which run intermittently, to *Calenders* (Fig. 10), *Mangles* (Fig. 12) and *Hydraulic Pumps* (Fig. 14), which provide an irregular load. *Cropping Machines, Measuring Machines* and *Calenderoys*, and, indeed, all machines which do not run continuously, should also be put on single motor drive.

The individual electric driving of calenders with chain transmission as illustrated has proved very successful in practice, and also a similar motor arrangement with gear or worm drive. A small motor, visible in the foreground, is provided for driving the auxiliary shaft.

For driving mangles laminated belting has proved satisfactory, the motor being of the slip-ring type, and fitted with a large flywheel to enable the peaks of the load curve (Fig. 11) to be negotiated.

(*To be concluded.*)

OBITUARY.

DR. ALEXANDER GRAHAM BELL.

Dr. Alexander Graham Bell, the inventor of the telephone, whose death took place on the 2nd of August, at his summer residence on Cape Breton Island, will certainly be remembered amongst the world's great inventors—men whose original work has profoundly affected the daily life of civilised mankind.

A Scotchman, born in Edinburgh in 1847, Graham Bell came of a family associated with the teaching of elocution, his grandfather in London, his uncle in Dublin and his father, Andrew Melville Bell, in Edinburgh, being all professional elocutionists.

Graham Bell was educated at the High School and at the University of Edinburgh, and in 1873 migrated with his father to Canada. It was there that he conceived his great idea of the speaking telephone, but the first instruments were not constructed till he went to live at Boston in the United States, where they were completed in the year 1875. Exhibited at the Philadelphia Centennial Exhibition in 1876, Bell's telephone immediately attracted worldwide attention. It was there that it was seen by Sir William Thomson, afterwards Lord Kelvin, who brought it to the notice of the British Association in Glasgow in the autumn of the same year.

As originally constructed, Bell employed the same or similar instruments both for transmitting and receiving. This gave very distinct, though somewhat weak, articulation, with the result that particularly over long lines, speech often became too faint to be practicable. It remained for Edison, Hughes and Hunnings to invent the more powerful microphone transmitters that are now used, but Bell's instrument, practically in one of the forms in which he left it, is still universally employed as a receiver. Seeing of how few parts it consists, and the wonderful results that it gives, it has been well described as an instrument of sublime simplicity.

It is unnecessary to enlarge upon the enormous developments in telephonic communications that have taken place all over the world since the date of Bell's invention, during the last forty years, but apart from its great commercial and domestic utility, it should not be lost sight of that Bell's telephone is a scientific instrument of surpassing delicacy for the detection of very minute electric currents. In this connexion, it has been put to many uses, and none more so than in wireless telegraphy, which could scarcely have arrived at its present advanced stage of development without it. Further, of course, without Bell's invention, wireless telephony could scarcely have existed at all. Out of the telephone both Graham Bell himself, and also his father-in-law, G. G. Hubbard, who assisted in the financing of the invention, made princely fortunes.

Another invention of Bell's was the photophone, in which articulate speech is transmitted along a beam of light. In perfecting this instrument, he was assisted by Summer Tainter. Though of considerable scientific interest, and used to some extent in the great war, this invention has never proved of commercial utility.

Of more practical importance was Bell's valuable contribution to the phonograph. In this instrument, as originally invented by Edison, in 1877, sounds and speech were recorded by indentations on tinfoil. This method gave very imperfect reproduction of the original sounds, until Graham Bell, assisted by his relative, Chichester Bell, and again by Summer Taintor, introduced, in 1885, a method of recording by means of a cutting style operating on wax. This method now forms the basis on which all modern gramophone and phonograph records are made. It should also be mentioned that Graham Bell took an early interest in aviation, being the chairman of an association of experimenters which, under the name of the Aerial Experiment Association, did much useful pioneer work as long ago as 1908.

Bell thrice honoured the Royal Society of Arts by personally lecturing to its members. His first discourse, which was on his telephone, was given in November, 1877, when the crowd to hear him was so great that large numbers of members were unable to obtain admission to the lecture hall. The Council thereupon requested Bell to repeat his lecture another day, which he did.

Bell's third lecture to the Society was on the photophone, and took place in December, 1880. Prior to this, he had been awarded the Society's silver medal for his previous paper on the telephone, and also in 1878, he was elected an honorary life member of the Society in consideration of his invention of the telephone. Further, in 1902, the Society's Albert Medal was conferred upon him. Amongst other honours, he also received the Hughes Medal of the Royal Society in 1913, and during a visit paid to this country in 1920, he had conferred upon him the freedom of his native city in Edinburgh.

Bell had an imposing appearance, but a very delightful and modest personality. Some years ago he told the present writer that he did not pretend to be an electrician; indeed, some of his friends informed him that he could not be one, as otherwise he would have known beforehand that his telephone would never work.

A. A. CAMPBELL SWINTON.

Journal of the Royal Society of Arts.

No. 3,640. VOL. LXX.

FRIDAY, AUGUST 25, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

DOMINIONS AND COLONIES SECTION COMMITTEE.

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, 26TH APRIL, 1922.

SIR JOHN F. C. SNELL, M.Inst.C.E., Chairman of the Electricity Commissioners, in the chair.

The paper read was:—

THE USE AND ADVANTAGES OF ELECTRIC POWER IN THE FACTORY, AS ILLUSTRATED BY ITS APPLICATION TO THE JUTE INDUSTRY.

By J. F. CROWLEY, D.Sc., B.A., M.I.E.E.

(*Concluded from page* 689.)

THE ADVANTAGES OF ELECTRIC DRIVING.

Much has been written in favour of electric driving in the factory and the workshop, and it would not serve a useful purpose to-night to go over old ground. There is, however, one outstanding feature of the drive which will probably, from what has been said, stand out in bold relief in most minds, and that is, the increase in the productivity of the driven machines that the proper application of electricity can give. The amount of this increase is dependent naturally on how far, in arranging the lay-out, advantage has been taken of the drive. It varies with the class of material dealt with, and while it is obtainable with group, as well as with individual electric drive, it is in connexion with the latter that it most definitely manifests itself. So far has this been recognised that, to quote a recent writer, Mr. W. Sutcliffe, "one of the largest textile combinations in this country decided, some years ago, after considerable experience, to adopt individual driving for all machines other than those connected with the preparatory processes, the chief factor influencing this decision being the superiority of the drive for spinning and

finishing as shown by the improved evenness and quality of the finished goods. This firm has now upwards of 11,000 induction motors operating in their various mills, the great majority of these being under 10 H.P. of the squirrel cage type and driving individual machines."

When it is added that the author has, during the past ten years, and notwithstanding the war, installed over 12,000 individual drive motors, it will be clear that the merits of this drive have come to be recognised by the most conservative manufacturers.

The great advantage of any increase in production secured from the drive lies in the fact that it is obtained without any increase in building space, productive machinery, rent, rates or taxes, and its effect on profits is consequently more striking. The author was able to show,* a few years ago, that an increase of 10 per cent. in the production of a Lancashire weaving shed which was obtained through individual electric driving was equivalent to an increase in profits of over 30 per cent., and while it has not been possible to obtain the detailed information necessary for a similar general investigation in the case of the jute industry, sufficient data has been obtained to show that for Indian jute mills in particular the effect on profits of such an increase is more nearly 50 per cent. than 30 per cent.

This is a striking result, and, in the author's view, furnishes a solution, if not indeed the only solution, of the problem that is facing the manufacturer who has put down a new mill, during or since the war, and finds himself forced to carry a very greatly increased capital expenditure and at the same time to compete with mills erected in happier circumstances, and the greater part of whose capital has, in many cases, been written off.

If electricity furnishes the solution of this serious war problem, and the author believes that it does, it will, as the Chairman pointed out in his opening remarks, have done for this generation what the steam engine of James Watt did for the generation that lived through the depression following the Napoleonic wars—an achievement that it must be conceded would be no mean contribution to the solution of the Peace Problems of the World. The author desires to acknowledge his indebtedness to the Chairman (Mr. McKenzie) and Committee of the Indian Jute Mills Association for very valuable assistance; to the Chairman and Secretary of the Association of Jute Manufacturers and Spinners, Dundee; to the Secretary of the Chamber of Commerce, Dundee; to Mr. C. R. Orr, Edinburgh, who kindly read through the proofs, and whose criticism was very helpful; to Mr. L. T. Miller, Dundee; and, finally, to the English Electric Company for permission to use the various photographs of plant.

*"The Individual Electric Drive in Weaving Sheds."—*Journal of the Association of Managers of Textile Works, March*, 1912.

DISCUSSION.

The Chairman (Sir John Snell) said that it was usual for the Chairman at these meetings to open the discussion, but on this occasion he was bound to say that he felt singularly incapable of beginning a useful discussion on account of the special knowledge which was required in connexion with the application of electricity to textile industries Some years ago he had a slight connexion with Dundee, at the time when that city was beginning to build its new power station, and the application of electricity to the textile mills in that town had to be considered. But it would be futile for him to criticise any of the special technical points in the paper. There were one or two general matters on which he might make comment. Dr. Crowley had remarked that there was a tendency to give up the individual generating plants and to take energy from a public source. He was glad to say that that policy was not confined only to the jute industry. He believed that the mills at Dundee were beginning to take their supply from the public system, but certainly in the Lancashire cotton area and also in the worsted area of Bradford and the West Riding there was an increasing tendency for the textile mills to utilise public sources. A few years ago there was a very heated controversy as to the relative advantages of the individual mill engine drive with long lines of shafting and the electrical drive, but the lantern-slides that evening had made it very clear, he thought, even to those who were not experts in the matter, that the absence of so much counter shafting and belting must have an important effect on the employee, not only from the point of view of lessened danger, but from that of lessened noise and distraction. He imagined also that it must have an effect from the point of view of the light available in the building, quite apart from the most important point of all—namely, increased production due to steadier drive. If one were asked to weigh up the evidence given by the author, though perhaps this was *ex parte*, one would say that he had made out a very clear case for electrical driving, and particularly by individual motors. Of course, he took it that an expert who had to deal with the application to textile mills was confronted with two problems: (1) the matter as it related to the creation of new mills, which

was perhaps the easier problem, because there he had a clear field, and anybody who looked at the pictures just shown of the galleries outside the actual factories, as it were, must have been struck with their neatness and easy accessibility, the better grouping of machines, and better design of factory as a whole, which was possible when the problem had to be tackled *de novo*. To those who were textile experts it might be that what he was saying was utter nonsense, but, speaking as a layman, that was the impression made upon him. But the second problem was the more difficult, the application of electricity to an existing mill. There Dr. Crowley had shown that instead of driving from perhaps the end of a shaft through long lines of cross shaft, by grouping the important motors in the middle of the system, not only was the total variation reduced by something like one quarter, but with the electrical drive the starting of machines was more prompt, so that there was an even greater gain. There could be no doubt —and it was a very important thing to a person in his position to have assurance on the point— that there was in these great industries, whether flax, or cotton, or jute, a recognition on the part of the manufacturers that electricity was bound to play a very important part, enabling them to cope more readily with increasing competition, not only from foreign countries, but even from our own Dominions overseas. In this country the tendency in the north and north-west of England was to rely more and more upon the public sources of supply. As he had indicated at the very beginning of his remarks, this country, with the increasing competition which it had to face from abroad, especially from those industrial countries that were blessed with many natural resources like water power, had got to put its last ounce as it were into increased production and reduced costs if it was going to maintain itself against competition effectively. It was of the utmost importance that there should be the completest accord between the great electricity supply undertakers, the electricity plant manufacturers, and the industrial manufacturers, so that instead of adding to the difficulties of the industrial manufacturer by causing him to put in his own generating plant, he might be able to save that capital money and get his supply from public sources with perhaps a greater degree of safety to his supply than would be the case were he dependent upon his own single plant. A liaison between the electricity supply undertaker and plant manufacturer and the industrial manufacturer ought to be an important factor in maintaining the satisfactory competition of this country with other countries and conserving, as he sincerely hoped would be the case, its industrial supremacy. The only other point upon which he would like to touch was this: it had been noticed that in India there was a very great tendency to introduce American electrical machinery. As was well known to many who were present, the standard frequency of that country was 60 cycles, whereas our standard frequency in this country was 50. It was important for us to remember that the Imperial Government of India had permitted large installations of 60-frequency plant to be introduced into that empire. This made it very difficult if not impossible to compete, or even to supply the separate parts for such machines. He devoutly wished—and he spoke from some official standing—that for the sake of the Empire as a whole and for the sake of our manufacturers at home there should be some understanding between the Governments of our great Commonwealths overseas and the Imperial Government, whereby at any rate the British standards should obtain throughout the whole of the British Empire.

MR. W. H. PATCHELL, M Inst C.E., said that the author had shown them very plainly that electricity was not a prime mover. He had also shown them another instance of the excellent means of transmission which it is; they did not yet know a better. The conversion of an old mill was a different proposition from the laying out of a new mill Dr. Crowley had spoken of mills with a shaft 700 feet long. The individual drive was absolutely the ideal theoretically, and the nearer one approached to the individual drive the more was friction cut out and production increased. But the pendulum must not be allowed to swing too far. Messrs. Coats at one time let in Ferranti, who tried an individual drive on each spindle. Electricity in the ordinary way would not supply steam, and that was a consideration, for exhaust steam utilisation represented a great saving in coal. What was the cost of driving in a textile mill? In England they were badly off for anything like details. They had to go abroad for useful data. The last data he could find related to 1914, and showed the cost of driving power and fuel in the textile industry to be 1.3 per cent. of the cost of the finished product. The other costs were:—

Raw material	57	per cent.
Wages	19.7	per cent.
Other costs and profit ...	22	per cent.

If, therefore, it was a matter of only 1.3 per cent. with which to play, the cost of the finished product was not going to be materially affected by varying the cost of power. Another point which came out in these figures was the average horse-power of motors, which had fallen very considerably, and showed the tendency towards the individual drive. He could say nothing about Calcutta, of which the author had spoken, but thirty years ago he assisted at setting up the first station in Dundee. It was a direct current station, 400 volts, three-wire. Like most other plants which were started direct current, it had now become alternating, and it was also interesting to note that the first jute mill which was started in Dundee—the author gave them approximately

the date, and it was many years before a mill was started in Calcutta—was on a site now occupied by a technical school, which did its best to teach young Dundee how to spin jute. The speaker added that he would like to say something about statistics. He believed what had most affected the price of current in this country was the publication of the costs. The Board of Trade got out schedules, which they did not use, but pigeonholed, whereupon one of our enterprising journals, the *Electrical Times*, performed a service which this country could never forget by analysing and publishing these statistics. He believed that this, more than anything else put those of them who were making juice into healthy competition with each other and brought down prices. Was it not possible now to get something useful in the way of statistics? With the Geddes axe hanging over their heads it might not be possible for the department over which the Chairman presided to set a large staff on to working up statistics, but he thought it might be possible when opportunity arose to get the undertakers to deliver to the department such statistics, not only on the financial but on the technical side, as would show what they were doing and would help them to do better. It was only in that way, by all putting their cards on the table, that they could make progress, and he believed that public utility companies ought to show to the public what they were doing so that the public might have the advantage. He hoped that one outcome of the paper would be that the statistics collected by the Chairman's department might be made more useful and more fully used, even though the analysis of them was left to private enterprise.

THE CHAIRMAN assured Mr. Patchell that the question of statistics was already in hand, and questionnaire forms had already been sent to the undertakers.

MR. THOMAS WOODHOUSE (Head of the Weaving and Designing Department of the Dundee Technical College) said that he had been in favour of individual driving for a number of years, but he could instance some little difficulties in connexion with that system for certain particular machines. Ten or eleven years ago he had nearly all the machines under his control individually driven. The advantage of the individual drive, apart from uniformity and increased production, was that a loom could be started even with the crank on the front centre. A difficulty often arose over the starting of some machines. There were machines which must start quickly, but others must start slowly, and the greatest difficulties from irregularity came from the machines themselves. He had been able to obtain a few picks per minute increase in individually driven looms, by means of a laminated belt, while he had first-hand information that an increase of 10 to 15 per cent. over steam-driven looms had obtained by individual motor drive. The gain, in his opinion, was not due in all cases to any large extent to increased speed, but to more uniform movement, fewer stoppages, and minimum breakages.

MR C. G. RENOLD said that he had been very much impressed by the point Dr. Crowley had made of the possibility of reducing the cyclical variation of shafting by the introduction of motors up and down the place and driving at a number of points instead of from one centre. This dispersion of the points of driving is very much facilitated by the use of chains. If one was going to hitch a motor on to the middle of a line shaft, one had the choice of doing it by gears, by belts, or by chains. There was nothing more difficult than to get gears sufficiently accurately aligned and this did not apply to chains. If belts were used the possible locations of the motor were very much restricted by the requirements of a satisfactory belt drive If chains were used the motors could be placed almost anywhere where space could be found and still a satisfactory drive obtained. The chain drive was, of course, equally positive with gears It would be interesting to know whether in connexion with the cyclical variation, the author had any figures furnishing a direct comparison between chains and belts. Some interesting experiments were made years ago in his own factory in the driving of automatic lathes. The test had been undertaken to measure the following features: Total production, quality of work, i e, finish of machined surfaces, life of tools, power absorbed, wear and tear of machines. The tests were made with the machines working at their maximum capacity. It was found that the speed was limited by considerations of "finish," the belt driven machine producing much rougher work than the chain driven. When both machines were run at the same speed (the maximum possible consistent with "finish" on the belt driven machine) the total output from the chain driven machine over a test of 138 hours was 23% greater than that from the other. This was due to a fewer number of stoppages for tool sharpening. The life of the various tools was from 4 to 5 times greater on the chain driven machine; the power absorbed was 20% less, due to the heavier loads on the bearings produced by initial belt tension, and the wear and tear of the machine bearings was noticeably less in the case of the chain driven machine for the same reason. The results as regards "finish and life of tools," with its consequent effect on total production could only be attributed to "chatter" set up by irregular slipping of the belt, or by its stretching and contracting in a kind of concertina fashion as the load changed, due to the various cuts. The chain, by giving a smooth regular turning, enabled the machine to do work beyond its normal capacity, to produce work of good finish and to get a greater life out of the tools.

The net result was a considerable increase in production. It would be interesting to know whether similar results had been noticed by the author. He was also interested to see some of the slides showing large mangles. He was not very familiar with the jute industry, but in the cotton industry it had been found a great advantage to drive these mangles and calenders by chains. In cotton work particularly, where a fine finish was wanted, driving by chain had a great advantage. One could eliminate, in this way, wave-marks on the fabric which were produced by the gears, and one could avoid quite a number of breakages—tearing of material —which one got with the gear drive. The advantage with the chain drive was attributed by the people who used it to a certain flexibility — the chain drive was so to speak "kinder to the fabric" than the gear drive. Possibly with jute the same condition did not hold good, due to the finishes not being so high or the fabric so delicate.

Mr. W. Sutcliffe said that Mr. Patchell had referred to the individual drive on each spindle which was designed by Mr. Ferranti for a large textile concern in Scotland, but it should be remembered that in this case the motors employed were of the pneumatic variety and not the electrical. Experimental jute frames, however, had been built with a small motor applied to each spindle, but obviously this was carrying individual driving a little too far, and needless to state the proposal never got beyond the experimental stage. There was no doubt, however, that every machine in a jute factory could be driven individually and the only two machines which presented any difficulty were the card and the mangle. In the former case a good individual drive could be obtained by employing a centrifugally operated clutch, which allowed the motor to attain nearly full speed before coming into operation; as regards the latter, Dr. Crowley had that evening, described to them a method of applying the individual drive, and they would be interested to learn that the drive in question had been in successful operation for the last eight years. Dr Crowley had referred to the practice of the Calcutta Supply Authorities in recommending their consumers to adopt high tension motors with stators wound for 3,000 or 6,000 volts, but it would be seen that this imposed a very great difficulty on the designer of the electrical layout, since it precluded the adoption of small motors owing to the impossibility of their being wound for the high voltage. In fact, it simply meant that such a recommendation put individual driving out of court altogether and left the consumer with little choice in the matter. He agreed entirely with Dr. Crowley that such a recommendation could not be too strongly condemned since it was an obstacle to progress. On the question of power factor, it had been stated that central station engineers would make an extra charge if the power factor of an installation dropped below a certain figure, and in his opinion no serious objection could be taken to this since it was well known that a low power factor had the effect of limiting the capacity of the generating plant and main system; on the other hand, however, he thought that an inducement should be given to users of electricity to obtain as high a power factor as possible, and in this connexion would mention that in Dundee and Glasgow most generous rebates were given to consumers whose power factors reached ·9. The curves shown by Dr. Crowley were most interesting, particularly those showing the cyclic irregularity at various points in the mechanical transmission of a weaving shed, and they confirmed his own ideas on the matter. It was well known that in some of the Dundee factories some of the larger looms could not be satisfactorily driven at the extreme ends of the shafts owing to the cyclic irregularities of the intervening shafting The extent of angular twist in a shaft was perhaps not fully realised, but it might be stated that with shafting over 300ft. long it became considerable. Shafting tables were usually based on a torsional stress of 5000/6000 lbs per sq. inch, and elementary calculation would show that any shaft loaded to that value would have an angular twist of 1 degree for every 20 diameters of shafting; that is to say, a loaded 4in. dia. shaft would have a twist of 1 degree for every 80in length. Taking the case instanced by Dr. Crowley, in which there was a shaft 700ft long, it would be seen that the angular twist at the extremity, assuming uniform distribution of loading throughout its length, would exceed 100 degrees. This would not be a very serious matter if the load were absolutely steady, but as a matter of fact such a condition never occurred and therefore the twist would be a variable quantity between the limits of zero and maximum, depending on the instantaneous load carried. In the practical arrangement of shafting it was, of course, usual to reduce the diameter at intervals along the length on account of the diminishing load and the effect of this would be to keep the torsional stress loading fairly constant; thus the figure for angular twist previously referred to, i.e., 1 degree of twist for every 20 diameters of shaft, would still hold good, but the calculations for a shaft so graded or tapered would show that the twist at the extremity, say of the 700ft. shaft, would be considerably worse than the figure he had previously given. He thought this was a point that perhaps in the past had not received the consideration that its importance demanded.

Colonel H. Sparks referred to the jute industry in the United States, particularly one large American concern. It was very difficult to say exactly what was the saving by the application of electric power. They started twelve

years ago in New York, and went through much of the experience which had been brought to their notice that evening. In the case of one mill the consumption of units was now about eleven million per annum. This large concern did not stop there, but went on with the electrification of their mills in other cities. These were cases of conversion. Next came the industry starting *de novo*. A mill was put down in Calcutta and worked on the same lines. That was one large American concern, and what it had done it had done successfully and was well worthy of consideration. One advantage of getting power supply from outside was that the manufacturer might then apply himself wholly to his particular industry—for example, jute. With regard to the individual drive, he believed that one of the biggest firms in the silk industry drove each spindle with an individual motor.

MR. PETER KILGOUR said that there was one point which Dr. Crowley had omitted, and which was of extreme importance—namely, the reduction in waste which took place under electric power If one sold waste one got coppers for it, and if one sold cloth one got pounds! The speaker mentioned an instance in which some spindles in a mill were driven direct with friction, Leslie's patent, instead of by means of a band. About fifteen years ago in a factory with which he was concerned, a few machines were put in to be chain-driven instead of belt-driven The chains after running four or five years showed no signs of wear, and the drive was so perfect that from 5 to 7 per cent. of wastage was eliminated. He mentioned also that in Dundee they had one shaft which, like the one mentioned by the author, was over 700 feet long.

DR. CROWLEY, in replying to the discussion, said that there was no time to reply in detail, and he could only refer to one or two of the points which seemed to traverse the paper more directly. With regard to the remarks of Colonel Sparks as to the development in textile work in America, of course America was definitely developing in the direction of individual driving, and was far more advanced in that connexion than Britain. It was quite unusual to find automatic looms there driven mechanically in the way they were driven here now. With regard to test results, definite test results were available in the textile factories of this country taken on machines driven in the old way and on the latest electrical system. If there was one thing more than another that the manager of a factory did know it was his output. He would append to the paper the results in one case in Calcutta. With regard to the spindle-drive question, Mr. Patchell had criticised a particular case, but this, as a subsequent speaker had said, was a case of a pneumatic drive. In the artificial silk industry the spindles, which were particularly heavy, were successfully driven individually, but the spindles in this case were heavy enough to justify it, whereas the smaller cotton spindles were not. In the old spinning frame of the normal standard type, it was not easy to realise the power that was lost, but by simply inserting in a frame, that had done duty for many years, an auxiliary tin drum, the number of spindles per horse power, which had been 11.2 before the drum was inserted, became 16 after the insertion. People had not realised the power that was lost in that particular case. In reply to Mr. Woodhouse, the difficulties presented by starting torques and the cyclic irregularity in torque of the machines had been completely got over in most cases. There were electrical and mechanical means of overcoming all these difficulties. The cyclic irregularity in torque of particular machines must be recognised. Such irregularity was particular to the machine, and the individual motor yielded to the varying torque and did not upset production, whereas what really did upset the machine were the oscillations of the driving shaft produced by other machines and imposed upon it at the wrong moment.

MR. PATCHELL, who had taken the chair, as Sir John Snell had had to leave the meeting, proposed a vote of thanks to Dr. Crowley, which was heartily accorded.

MR B. J. M. LANE, B.Sc., A M I E.E., writes :—

Dr. Crowley, who has done a large amount of pioneer work in connexion with the application of electricity to mills and factories, has been able to speak with authority on this interesting subject, and has incidentally covered a large range of work.

The author has referred to restrictions mad by certain supply companies with regard to the power factor. This is a much-discussed point, but it is generally recognised that there should be a differentiation between consumers working on a low power factor and those working on a high power factor. Where such technical regulations exist, they tend to have their effect upon the motor mill equipment, as for instance, to the detriment of flexibility of the drives. Means may be used to comply with this restriction without interference with the best arrangement of the mill drives. I refer particularly to the means already mentioned by the author, viz., to the use of the asynchronous-synchronous motor or the oscillating phase advancer set. One machine, or possibly two or three machines of this type, depending upon the amount of power factor correction required, may be used in the place of the ordinary induction motor for the drives where the largest amount of power is being consumed. Such machines are by no means new and they already possess a fair field of application. Their cost is not very much above that of an ordinary

induction motor of the same size and speed, so that this point forms no stumbling block, and the extra switchgear involved is small.

On comparing the relative costs of asynchronous-synchronous motors with standard induction motors I find that the cost of asynchronous-synchronous motors up to 200/300 H.P., and down to approximately 428 R.P.M. is 25 to 30 per cent. more, whilst on the higher outputs this figure drops to approximately 15 per cent. On low speeds, say 214 R.P.M., the prices are approximately the same.

The cost of an oscillating phase advancer set lies approximately midway between that of the induction motor and that of the asynchronous-synchronous motor, that is, a 200/300 H.P. phase advancer set of 428 R.P.M. or above would be approximately 15 to 20 per cent. higher than the induction motor price. Below about 428 R.P.M. the price is practically the same as that of the induction motor.

Salient-pole type synchronous motors figure at approximately the same price as the asynchronous-synchronous machines.

One great advantage of the application of the asynchronous-synchronous motor or the oscillating phase advancer set lies in the fact that power factor correction takes place at the seat of the trouble, so that the idle currents in the transmission lines are avoided. This is not the case where special provision is made at the generating station.

The systems of electrical driving in factories and workshops, fall under the two headings of group and individual drive, but one generally finds that a combination of both systems can be employed to the best advantage, the group system being most applicable where the machinery is running continuously for long periods on approximately full-load, and where the process does not call for special features, such as an absolutely uniform and steady speed.

In textile work, group drive applies therefore, particularly to the preparation machinery, whilst the weaving sheds may advantageously be equipped with individual drive, which, although initially the more expensive form of drive, carries with it the great advantage of increased production. This is a point which has been illustrated in a most interesting and convincing manner by Dr. Crowley, whose records taken from Indian textile mills on the variation of the line shaft speeds are, I think, almost unique.

Various suggestions have been made to overcome this line shaft speed variation, as for instance the use of heavier shafts with suitable stopping, and the introduction of flywheels. It is evident, however, from the information that Dr. Crowley has been able to give us that great care should be exercised in the grouping together of the various machines for line shaft drive, for cases have occurred in which it has been found necessary to re-group the machines before a satisfactory drive could be obtained. I would refer you in this connexion to the article in the *Textile Recorder* which has been already alluded to.

The line shaft speed variation has its greatest effect where materials of a fine quality are being manufactured, and especially in the spinning and weaving departments. Even with coarse material it is certainly desirable that drives of an impulsive nature should be so grouped that the effect of the sudden variations in power is not transmitted to other more sensitive machinery. For this reason, such machinery as jute softeners, mangles, calenders and pumps can advantageously be individually driven.

Jute softeners lend themselves to individual drive. A softener is usually started up light, but it is possible that a stoppage may occur during the process, in which case a re-start would have to be effected against at least full-load torque. It is an advantage to be able to reverse in the event of a choke, although a choke cannot be cleared by simply reversing the motor, and for this reason it is sometimes thought advisable to retain the large driving pulley on the softener for making a number of small movements by hand. The belt also forms a more yielding drive than a chain in the event of a choke, and so is more likely to avoid possible damage to the rollers or bevel wheels.

Jute mangles are difficult to drive owing to the heavy and frequent power fluctuations. The power for a 120-in. mangle will fluctuate from 0 to approximately 80 H.P. every few seconds, and these rapid reversals are very heavy on the clutches, there being two crowned clutches driven in opposite directions, and engaged alternatively by an ordinary cam motion. Jute manufacturers would be only too pleased to get rid of this arrangement, so expensive in its upkeep.

Mangles, of course, may be grouped together, and so driven, but it will be found that in such groups there are moments where the peak loads of perhaps two or three will coincide, which still makes the use of a flywheel and slip resistance desirable.

Jute calenders lend themselves to individual drive, and present no difficulties. A chain drive may very advantageously be employed with the individually-driven calender. Such an arrangement eliminates the open and cross belts driving through friction cones, together with the clumsy lever for engaging or disengaging either cone. There is, moreover, prompt and flexible control.

Various methods of the application of the motor drive where line shafting is employed for the group drives have been given by Dr. Crowley. Where the motor is applied at the middle of the line shaft any speed variation due to fluctuating loads is, of course, reduced to a minimum. It is, however, usually found more

convenient to drive from one end of the shafting as this permits of the placing of the motors in a motor alley-way, clear of the mill proper, the motors and switchgear being fairly free from the mill dust. This is especially the case where the scheme is one for conversion from steam to electrical drive, as there is a rope alleyway usually in existence.

Chain driving has, of recent years, come very much to the front in this class of work, and special attention has been given by leading chain makers to such requirements. Such drives have a very high efficiency, 97-98 per cent., which does not appreciably deteriorate during the life of the chain, which life, with efficient lubrication, may be put at approximately seven years. A fairly large reduction ratio may be used, meaning that the motor itself may be run at an economical speed, and the drive is smooth and positive. Gear cases and efficient lubrication are found to be highly desirable in textile work.

AGRICULTURAL CONDITIONS IN MOROCCO.

Morocco is a Moslem Sultanate on the eastern shore of the Atlantic Ocean. Its boundaries to the north, east, and south are the Mediterranean Sea, Algeria, and the Sahara Desert.

The Shereefian Empire was founded at the close of the seventh century by Arab invaders, who named it Maghrib-El-Aksa—the "Farthest West." In 1912 the country became a French protectorate, except that the port of Tangier and its immediate hinterland of about 140 square miles is under international control, while a zone extending 207 miles along the Mediterranean Sea from the Atlantic east to the Mulawia River, varying in width from 40 to 65 miles and containing 8,740 square miles, is administered by Spain. The zone of the French protectorate comprises 160,711 square miles, more than one-half of which area (92,664 square miles) is now effectively occupied and under French control.

With a total area of 169,591 square miles, Morocco is somewhat larger than California. The most reliable estimate places its population at 7,023,000; the average density is therefore 41 persons to the square mile. Tangier is estimated to have 63,000 inhabitants, the Spanish Zone 1,075,250, and the French Zone 5,884,750.

In the course of a lengthy report dealing with agricultural conditions in Morocco, from which the following is taken, the United States Vice-Consul at Tangier points out that agriculture is the only important industry in Morocco, where manufacturing in the modern sense may be said not to exist, while the mineral resources of the country are as yet undeveloped. But 10 per cent. of the population of the Shereefian Empire live in the ports and interior cities, the vast majority inhabiting the rural districts and directing their energies to food production and cattle raising, from which basic industries are derived all the commodities at present entering into the export trade of the country.

During the war and immediately thereafter Morocco made notable contributions to the food supply of its French protector, shipping to France (from 1915 to 1919, inclusive) a total of 18,460,929 bushels of barley, 3,376,818 bushels of wheat, 3,401,699 bushels of beans, 2,957,247 bushels of corn, 1,146,402 bushels of chick-peas, 1,091,109 bushels of sorghum, 27,504 short tons of eggs, and 75,987 hogs.

In northern Morocco the Rif Mountains describe a regular curve along the Mediterranean from Djebel Moussa (the second Pillar of Hercules), opposite Gibraltar, to Cape Tres Forcas, north of Melilla. The culminating point in this range appears to be Djebel Tiziren (8,125 feet) in the Djebala region. The Rif chain rises abruptly from the sea, but toward the interior of the country its slope is more gentle.

However, the predominant topographical feature of Morocco is the Atlas Range, the snow-clad peaks of which rear their heads 9,000 to 12,000 feet above the sea. The High Atlas chain commences at Cape Ghir on the Atlantic coast, somewhat to the north of Agadir, and stretches away in a north-easterly direction, attaining an altitude of 11,480 feet at Djebel Ogdemt, which, with Djebel Ouichdan (8,200 feet), dominates the valley of the Goundafi. Between the Goundafi and the Tizi-n-Telouet are the culminating peaks of the High Atlas, the Tizi-Tamjurt and the Tizi-Likoumpt. East of Tizi-n-Telout the High Atlas range is a series of parallel heights, separated by plains and rising gradually up to the principal chain, which attains an elevation of 12,713 feet at the Ari-Aiachi. From the Peak Tizi-n-Telremt (7,156 feet) the High Atlas Range rapidly descends in height towards Algeria.

The Middle Atlas Range is formed of three chains, the most western commencing at the Ari-Haiana (9,840 feet) and ending with the Djebel Tazekka, south of the city of Taza. The highest summit of the central chain is the Djebel Moussa ou Salah (10,558 feet). South of Mequinez and Fez the country of the Beni M'Tir and Beni M'Guild tribes is a plateau rising from 3,280 to 8,200 feet and partly covered by oak and cedar forests.

The Anti (Southern) Atlas Range separates from the High Atlas at Djebel Siroua (11,480 feet) and continues in a south-westerly direction toward the Tazeroualt, between the rivers Sous and Draa, where its altitude is 4,920 feet. East of the Djebel Siroua extends the vast plateau region of the Draa and Tafilalt, 6,560 feet above the sea.

In size, as well as from an agricultural standpoint the French Zone is by far the most important part of Morocco, as within its limits are practically all the arable lands of the country. The fact

that a state of armed insurrection still prevails throughout a large part of the Spanish Zone necessarily reacts unfavourably upon the agricultural development of that part of the Shereefian Empire, the soil possibilities of which cannot be accurately judged until areas now closed are opened to investigation. However, its surface is extremely rugged, and, so far as is known, good farm lands are to be found only in the eastern and western extremities of the zone administered by Spain, particularly to the south and east of Melilla and in the triangle formed by the towns of Arzila, Laraiche, and El-Ksar el-Kebir It is stated that a large part of this latter area is sown to cereals.

In the French zone the mountainous surface of the Atlas region naturally precludes any possibility of agricultural development, while only the northern part of eastern Morocco is arable Farming is therefore restricted to the great undulating plains that extend some 325 miles along the Atlantic littoral from Mogador northward to within 50 miles of the Strait of Gibraltar, and inland about 100 miles up to the foothills of the Middle and High Atlas.

Bounded on the west by the Atlantic Ocean, agricultural Morocco may be considered as lying within a line drawn from the port of Mogador inland to Amismiz (a town 31 miles south-west of Morocco City), then north-east along the foot of the snow-clad Atlas to the city of Taza, and west to rejoin the ocean at Larache, in the Spanish Zone. The territory thus delimited comprises 36,700 square miles. Cultivated farm lands cover approximately a quarter of this area, or 8,500 square miles; while there are 200 square miles of orchards, vineyards, and gardens, 18,150 square miles of pastures, 7,750 square miles of uncleared land, 300 square miles of swamps, and 1,800 square miles of forests, in addition to the nearly 4,000 square miles of wooded lands to be found in the zone of the French Protectorate elsewhere than within the confines of the essentially agricultural zone above defined.

Land bordering the coast and extending 15 to 20 miles into the interior generally consists of a light siliceous soil, rich in humus, slightly acid, in places lacking lime (despite the calcareous sub-strata), and ranging in colour from dark amber to brick red. In places this formation gives way to stretches of sandy soil, more or less stony, but showing surprising fertility under cultivation. Behind this coast belt the soil is a heavy black loam, rich and relatively deep, slightly acid. It is excellent wheat land but rather difficult to work advantageously in seasons of continued rainfall.

Monotonous in aspect, and treeless from Casablanca southward, agricultural Morocco includes the well-watered Gharb and Beni-Ahsen stock-raising regions and the great cereal-producing plains bearing the names (from north to south) of Fez, Mequinez, Rabat, Chaouia, Doukkala, and Abda. The three last-named regions are especially noted for their fertile black soil, which reaches a depth of about 15 inches in Chaouia and varies between 3 and 4 feet in the Abda and Doukkala districts.

From sea level, this rich coastal belt gradually rises in elevation to an altitude of about 980 feet, where commences the zone suitable principally for stock raising, but including the plain of Morocco City (Marrakesh), which forms the central part of an irrigated district between 18 and 24 miles wide and extending some 125 miles along the foot of the High Atlas to the town of Tadla Although the soil of this elevated zone is mostly poor and siliceous, by the use of irrigation much fruit and good crops of wheat and barley are obtained in certain parts, where, it is claimed, cotton and sugar cane once thrived This region ends at an elevation of about 2,230 feet, where commences the forest and mountainous zone

From the following table it will be apparent that the staple crops in Morocco are barley and wheat; corn, sorghum, oats, canary seed, and millet are next in importance. There are also various regional crops, such as fenugreek, coriander, flaxseed, chick-peas, and beans. Potatoes, string beans, tomatoes, and other vegetables are little grown in Morocco. The crop yields in French Morocco during the period 1917-1919 were :—

Crops.	1917	1918	1919
	Bushels.	*Bushels.*	*Bushels.*
Wheat	15,623,608	22,649,517	16,356,747
Barley	31,582,659	35,143,395	26,338,954
Corn and sorghum ...	4,782,505	4,595,171	3,107,531
Beans	1,270,401	1,631,351	1,162,021
Flaxseed	128,032	563,078	608,471
Chick-peas ...	523,193	690,234	486,123
Oats	165,089	266,550	200,544
Millet and canary seed	290,972	227,361	53,442
Peas	15,855	18,274	71,049
Total	54,382,314	65,784,931	48,384,882
	Pounds.	*Pounds.*	*Pounds.*
Fenugreek ...	1,714,900	10,168,180	24,336,840
Coriander ...	3,217,720	13,904,660	3,452,680
Total	4,932,620	24,072,840	27,789,520

The wheat mostly grown in Morocco is the hard variety. The average yield obtained by native culture is about 10 bushels per acre. The Moors distinguish several ill-defined varieties of hard wheat. With a view to facilitating local trade in this cereal, a rational classification is being studied by the authorities. The Moroccan wheat generally known as Zrea has a long oblong grain, completely filled, is of a clear yellow colour, and somewhat resembles

the Mahmoudi wheat of Algeria and Tunisia. It is in demand for sowing in rich soil. "Asker" wheat, on the contrary, is more suitable for making hard-wheat flour, and it has a short, small grain, often wrinkled, and is gray in colour. It is cultivated in poorer soils, and even grows in the sand of the seashore.

The cultivation of soft wheat was formerly unknown in Morocco, but, as a result of official encouragement (including the payment of bounties) some 31,485 acres were sown to soft wheat in 1919, compared with 26,125 acres in the previous year. The varieties cultivated are the so-called tuzelle or Oran, and especially the bearded wheat with long grains, imported from Algeria.

The barley raised in Morocco is a 4-row winter cereal resembling in quality that of Algeria; the grain is short and inflated, sharp-edged, and has projecting sides. The average yield is 40 bushels an acre. From 1914 to 1918 a bounty was offered for each bushel of barley produced by European methods and delivered to the authorities.

Oats have been grown in Morocco only since 1912, but their cultivation is slowly increasing—from 3,706 acres in 1915 to 19,900 acres in 1920. The variety grown is light, but of good quality, being of the type produced in Algeria.

Maize thrives well in the rich and deep soil of certain regions of Morocco, especially on irrigated land, although in the coastal belt good yields are obtained without irrigation. Sowing generally takes place in March and the crop is ready for cutting at the end of June. The yellow is the variety principally grown, though early white maize is extensively cultivated in the irrigated districts of Southern Morocco. During the period 1914-1918 maize grown according to modern methods and sold to the authorities received a bounty.

White sorghum is cultivated in Morocco for its grain, from which the natives obtain a flour as much appreciated as that made from wheat. Although the varieties grown are generally white, of medium size, there is also a gray, smaller type. The dry cultivation of Minnesota sorghum was tried at Kenitra in 1917 and a yield of 36 bushels of grain and 129 bushels of green fodder per acre was obtained.

Winter crops in Morocco comprise barley, wheat, oats, beans, flaxseed, fenugreek and canary seed. Barley is sown first, as soon as the sun has dried the earth after the first autumn rains—that is, about the beginning of November in a normal year. Wheat, late barley, and oats are sown in December, and even in January, when the persistence of the rains makes it necessary to wait until then. Cereals rapidly mature and vegetation is much benefited by the sunshine that follows the March rains. The barley harvest commences in May, followed by wheat and oats toward the end of that month, and prolonged until June. At the same time the harvest of flaxseed, fenugreek, and canary seed takes place. The treading out process commences at once and continues into July and August.

The spring cultures, consisting of maize, sorghum, chick-peas, lentils, etc., are sown at the end of February and during the month of March; they are reaped in August and thrashed in September.

Haymaking takes place at the end of April and during the first part of May.

The principal kinds of soil found in Morocco are as follows (native names):—

Tirs.—A rich black soil of great fertility, especially in rainy years. It is slightly wanting in lime but is strongly impregnated with oxides of iron.

Hamri.—Generally red in colour; it is fertile and rich in silicates.

Remel.—Light, sandy soil.

Harroucha.—Contains lime and silicates, but is often stony.

Dahs.—Heavy alluvial soil of a clay nature containing silicates.

These different kinds of soil are found in nearly all regions of Morocco, but, in addition to the fact that their composition renders them more or less useful for cereal production, there are large areas still covered with dwarf palms and jujube and not capable of being cultivated until after clearing

The native agriculturist in Morocco is not a scientific husbandman. He has, indeed, some idea of the advantages obtained from the rotation of crops and is aware that he should not sow wheat in the same field during several successive years, but his cultivation is generally very superficial, the soil being ploughed only when sowing is actually to be undertaken, while spring and summer soil preparation is completely unknown. The grain is sown broadcast, and usually too thickly. No fertilisers of any kind are used; there is no weeding or hoeing; and, from the time the seed is sown until harvest, no cultivation takes place. Reaping is done with a sickle.

The authorities of the French Protectorate have added to their educational programme the professional agricultural instruction of natives, with a view to training young men who will be capable of directing horticultural work and truck farming and assisting the European colonists in their farming enterprises. Courses in horticulture and viticulture are therefore being given in the Franco-Arab schools of Mazagan, Petitjean, and Temara (near Rabat). Instruction in market gardening and arboriculture is also given in the schools of Ain-Cheggag and Bahlil, near Fez.

Working on shares is a practice common in Moroccan agriculture. Associations between landowners and farm labourers to this effect are the subject of oral or written agreements

witnessed by two adools (notaries). Although each region of Morocco has its particular usages in this respect, agreements to divide the crop on the basis of a fifth or a half are general throughout the country. In the case of a division at fifths, it is customary for the landowner to furnish the land, implements, work animals, and seed, while the labourer supplies only his work and skill. When the agreement provides for a division of the crop by halves the land and half the seed are usually furnished by one party, while the other supplies the work, animals and the remainder of the seed; taxes and costs are borne equally by the two associates. Occasionally, two small landowners form this kind of relationship, each contributing his land, labour, and one-half the seed, the crop and any costs being divided equally.

Although the two forms of association above described are general, there are others, such as those in which the landowner furnishes only the land, the other party supplying the seed, labour, animals, and paying the taxes and costs; or unequal portions of the seed are contributed The division of the crop then takes place according to previous agreement. If modern power farming ever takes on any considerable extension, in Morocco, new forms of temporary agricultural partnership will undoubtedly come into existence, whereby owners of tractors and other power-driven farm machinery will operate their equipment on behalf of Moorish landowners in exchange for a share of the crop obtained.

During 1920 the Franco-Moorish Government advanced, without interest, more than £20,000 to the 39 native farmer organisations created in the French Zone during the last few years. In forming and subsidising these groups in the various farming communities of the French Zone, the purpose of the authorities was to augment the food production of the country by enabling the Moorish farmers to enlarge and better their agricultural equipment and their herds; to contract collective insurance against hail, fire, and cattle mortality; to form co-operative buying and selling societies; and generally to foster their material welfare by the lending of mutual assistance in cases of sickness, accident, epidemics, locust invasions, and other adversities or calamities. Where poor crops prevent any of the 371,771 members of these groups from retaining sufficient seed grain to sow for the following year, money is loaned from the common fund for the purchase of seed.

These co-operative groups have shown a particular interest in the purchase of modern agricultural equipment, especially ploughs and winnowing machines, which are rented to members in turn, at nominal charges. The advantages obtained from the use of modern farm machinery are, therefore, being more generally appreciated by the native Moorish farmer; and this increasingly wider familiarity with such equipment may be expected gradually to have an effect upon the quality and yield of field crops in Morocco, as it also opens up new possibilities for the sale of farm implements and machinery.

The difficulties met with by the Moroccan farmer in obtaining loans from banks in the various centres of the country caused the Sultan to issue a decree, dated January 15th, 1919, instituting and organising in the zone of the French Protectorate an agricultural credit system on a basis substantially similar to that of agricultural credit in France At the base of this system in Morocco is the local caisse (office) handling directly with its members the various operations affecting farm credits. These several local offices are affiliated with two central offices, the one at Rabat and the other at Casablanca. These central offices discount the duly endorsed notes of members of the local offices, and may also make advances to the local offices' operating funds The Franco-Moorish Government has already advanced, without interest, approximately £24,000 to the two central offices referred to, which are the intermediary between the State and the local offices.

Chambers of agriculture have been established at Rabat and Casablanca, with jurisdiction over these two regions of Morocco, where the infiltration of French colonists has assumed its largest proportions.

There are also mixed chambers of commerce, industry, and agriculture at Morocco City (Marrakesh), Fez, Mazagan, and Saffi The role of these organisations is to study the means of developing the agricultural riches of the country and to place before the authorities the views of the farming element in matters of rural economy and agricultural technique

Although the immense majority of the farming class in Morocco are native Moors, many Europeans have entered the country in recent years for the purpose of exploiting its commercial and agricultural resources

About 400 European colonists (mostly French) are now established in western Morocco. The area in their possession is estimated to be 444,780 acres, of which 370,650 acres belong to Frenchmen. Among these settlers are certain important companies that hold considerable tracts up to 24,700 acres, but in the aggregate the lands they own do not exceed a total of 148,260 acres.

In eastern Morocco a certain number of European settlers have been established since the year 1907, many coming from the region of Oran (Algeria), where they had acquired experience in North African farming. There are now about 90 colonists there, who own a total of more than 94,000 acres, for the most part in farms ranging from 25 to 175 acres. However, several colonists hold some hundreds of acres, especially in the region of Berkane, where there are properties ranging from 750 to 7,500 and

even 10,000 acres. No large agricultural companies are included among the colonists in eastern Morocco.

In 1917 a new impetus to the agricultural development of Morocco along modern lines was given through the inauguration of a movement to encourage French settlers to take up farm lands in the zone of the French Protectorate. This movement comprises three categories of colonisation, namely, small, medium, and large. Small colonisation comprehends truck gardens in the immediate vicinity of urban centres, while medium and large colonisation is a populating movement, having for its object the settlement of a French farming class on lands especially chosen, in proximity to railways. Persons desiring to participate in these colonisation schemes draw lots for the purchase of certain lands or submit sealed bids, the latter method being especially required in the case of farms intended for large colonisation. Payment for these lands is made in instalments. Under the term "large colonisation" are included lands the nature of which is such that they cannot readily be divided into medium-sized farms, or of which the exploitation would require important capital. The reinforcement of the European farming element in Morocco, implied by the continued progress of this colonising movement, foreshadows a correspondingly increased demand for up-to-date farm equipment in a country long closed to all modern influences, agricultural or otherwise.

A decree by the Sultan under date of August 12th, 1913, instituted in the zone of the French Protectorate in Morocco a system of land registry designed to stabilise ownership of rural and urban real property by determining the exact topographic and juridical status of such property and removing all doubt concerning its ownership. This object is effected by means of "immatriculation," or the enrolment upon special registers of all available information concerning a given piece of real property, the determination of its ownership being followed by the issue of a title deed, upon which particulars of all subsequent transactions affecting the said property are inscribed.

The land registry system referred to has not yet been extended to the entire French Zone of Morocco, but is at present confined to the Atlantic coast regions of Rabat, Casablanca, and Doukkala, as well as to the Beni-Snassen region of eastern Morocco and to the town and district of Oudjda on the Algerian border.

From the time this land registry regulation became effective, on June 15th, 1915, until January 1st, 1920, application has been made for the registration of 3,132 properties, covering 434,490 acres. Of this area, 4,775 acres were urban properties and 429,715 acres consisted of rural holdings.

UTILISATION OF THE EAST AFRICAN BAMBOO.

The East African bamboo grows on the high plateaux and mountains of the Colony of Kenya at an altitude of from 7,500 to 11,000 feet. The bamboo forests cover large areas, in some cases many square miles in extent.

The principal bamboo forests are situated on the Kikuyu and Mau Escarpments, the Aberdare Mountains, and the slopes of Mount Kenya and Mount Elgon. The nearest edge of the bamboo forest is about three miles from the railway. The forests are well watered by numerous streams, many of which are of sufficient volume to provide power. Since they are situated at a high altitude, the climatic conditions are well suited for Europeans, but not so well adapted to those Africans whose homes are in the warmer parts of the colony. They, however, soon become acclimatised and do not object to living and working in the cold districts

According to a report by the United States Consul at Nairobi, it is estimated that the cost of felling and transporting bamboos for a distance of half a mile would be from £5 to £6 an acre. This estimate is based on the cost of manual labour and human porterage only. Organisation and supervision would greatly reduce the cost A fair amount of unskilled labour is at present available

Although the yield of pulp from the African bamboo is somewhat low compared with that obtained from the Indian, the results of experiments show that a good strong paper, suitable for writing purposes, can be produced. About 1·5 tons of the bamboo were heated with an extra strong solution of caustic soda for 12 hours, and a pulp was obtained which bleached satisfactorily and yielded white paper of good quality. The pulp was converted into a pale-tinted paper, the yield of which (including loading and size) was found to be 41 per cent. of the weight of bamboo treated.

The Government of the Colony and Protectorate of Kenya is inviting offers for the lease of two areas of bamboo forest on the Kikuyu and Mau Escarpments. No tender of less than 2*s*. a ton will be accepted, the basis of the tender being a royalty payment per ton of air-dry pulp. Licences will be granted to the successful tenderers for periods of 20 years, with options for renewal on terms to be agreed upon. Exclusive right for 20 years will be given the licensee to cut bamboos for the manufacture of paper-pulp over an area to be selected by him in conjunction with the Conservator of Forests within five years of the date of the licence. The areas are estimated to be capable of yielding annually 40,000 tons and 20,000 tons of paper-pulp respectively. Offers must be forwarded to the Conservator of Forests, Nairobi, Kenya Colony, on or before April 1st, 1923.

OBITUARY.

VISCOUNT NORTHCLIFFE, LL.D.

By Lord Montagu of Beaulieu, K.C.I.E., C.S.I.

No man of our time has had so many varied obituaries written about him as the late Lord Northcliffe. We have seen him pictured in his youthful years as a cyclist and a reporter on one of the cycling papers. It has been related how he started *Answers* with almost immediate financial success. And still later we have heard of him as a great power in the land, almost able to make and re-make Governments, voicing in a curious and persistent way the immediate view of "the common people good enough for me," as Rudyard Kipling says, where lies the residual strength of the British nation. For my part I only intend to write about him as an intimate friend for many years. The chief characteristics that struck me were his power of vision and his personal charm and kindness. Above all was his untiring energy. We have seen it stated that it was this superhuman energy which wore him out, but in reality I do not believe it was anything of the kind. He had at one time a threatening of blindness and afterwards a painful swelled gland in his throat, from both of which maladies he entirely recovered. But the fatal "Streptococcus" germ which found its way into the blood stream was too deadly even for him. When I saw him as recently as last February in India I found him in excellent health and spirits, brimming over with ideas and energy, and then, as ever, confident of the future and of the recovery after the war of the Empire, and of the nation's power to solve the many difficult problems with which India and the great dominions teem.

He had a great regard for science and for the work of the leaders of research, as those conversant with the lectures at the Royal Society of Arts will remember. He often said to me in reference to automobilism, aviation and road-making, subjects in which I was very closely in touch with him, how much further detailed research was needed, and how the hand to mouth methods of the past, especially in regard to road-making, would have to give way to the scientific treatment and construction of our highways.

In his private life no one could have been more charming as a host or as a companion. He was intensely devoted to his old mother, who survives him, to his family and to his many nieces and nephews. But there was always a tinge of sadness about his position at home, for though he was devoted to his charming wife, he lacked that which he would most have prized in his life—children of his own. Who can say if he had had the softening ties of a family how much more toned down his restless temperament would have been? But as it was the impelling force of great energy and the fund of new ideas ever welling up forbade him to rest. When he was resting from his actual work or his business, as sometimes in the South of France, he was thinking, planning, scheming for the future. It has been well said that you cannot judge an extraordinary man by ordinary standards, and when you are considering the life and character of Lord Northcliffe, you must realise that when he was convinced that a policy was wrong, or that England was in danger owing to the action of this or that individual, he was relentless to the last degree. He would accept no compromise, and proceeded with grim determination to destroy the thing which he hated. This can be seen by remembering what he did about munitions in the war, and in my opinion history will justify what he did by his fierce attack on what seemed to be weakness on the part of the Government towards Germany at one or two critical periods since the war. If he had to entirely cut himself adrift from his friends who stood for or against the policy he approved or disapproved, he did so ruthlessly and often almost bitterly. He was afraid of nobody and nothing—his courage was immense—and England loses a patriot.

Many of us who, like myself, knew him well, will always cherish the remembrance of him as a wonderful companion in many delightful hours on the road at home and abroad, as a brilliant parent of new ideas, and, at any rate in his private life, entirely simple, unspoiled by the possession of money or power, using both according to his lights for the good of mankind and of the Empire.

Viscount Northcliffe joined the Society in 1916, and in the same year was elected a Vice-President and member of the Council, his term of office expiring in 1919. He was re-elected last year. He attended a meeting of the Colonial Section (now the Dominions and Colonies Section) on 11th April, 1916, when a paper on "The Forest Resources of Newfoundland" was read by Sir Daniel Morris, and took

part in the discussion In 1917, the Council, with the approval of the President, H R H. the Duke of Connaught and Strathearn, awarded the Albert Medal of the Society to Mr Orville Wright in recognition of the value of the contributions of himself and his brother, the late Mr. Wilbur Wright, to the solution of the problem of mechanical flight The medal was forwarded to Mr. Orville Wright at his home in America—Dayton, Ohio—through the British Ambassador at Washington, and formally presented on 27th October, 1917, the ceremony, at the request of His Excellency, being performed by Lord Northcliffe, then in the United States in connexion with the War Mission, of which he was the head

NOTES ON BOOKS.

The Metallurgy of Iron and Steel Compiled by the Editor of Pitman's Technical Primers (R E. Neale). London: Sir Isaac Pitman and Sons, Ltd 1922 2*s* 6*d*. net

This small octavo, so thin as to rest unnoticed in the breast pocket of one's coat, arrives with the suggestion that it may prove of some service, especially to the student; but a casual observer may not realise how this can be possible in the present day of large and detailed treatises

Our monumental text books sometimes tend more towards the minutely instructional aspects than such educational aspects as comparative notes, and other stimulants of a personal expansion of mentality; but the purpose of the book before us is evidently to stimulate the mental or reciprocal interaction between instruction and education Turning to p 16, we find a schematic section of a modern blast furnace, not drawn with minute structural detail, but highly suggestive to a well-informed student who has read the short paragraphs on the opposite page, in which the five chemical and physical stages are summarised Our student, if moderately intelligent, will connect these stages with the gradual changes in aspect of the ore, fuel, and flux, as so effectively depicted in the sketch, but the first bright light will step in when the student considers the inner meanings of the temperature curve which is shown alongside the furnace, and when he revises his first impressions by reference to the tabulation of melting points and "industrial temperatures" on pp 96-97.

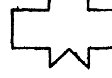
The student may now realise how much the heat immediately over the hearth is in excess of what may appear necessary for fusion, and he may reasonably conjecture that the function of this excess of heat is to lower the surface tension of metallic particles already in a fused state.

The educational spirit being now active, our student may think of ancient methods of reduction more or less like the Catalan forge method, in which it is practically essential to use a nearly pure oxide of iron like hematite or magnetite; methods which involve the compression or welding of softened spongy iron, and thus have analogy with Wollaston's method for platinum, also with certain modern methods for tungsten His mind may now drift back to the commencement of the book and the question raised on p 1 as to the possiblity of iron metallurgy having originated by the accidental heating of a piece of iron ore in a prehistoric camp fire. All that we have to suppose is that a piece of magnetite or hematite had been heated in a reducing part of the fire sufficiently long to be thoroughly deoxidised, and that it was suddenly compressed by a shifting of the boulders or stones used for encircling the fire A careful and ingenious student would perhaps at this stage imitate this sequence by a rather prolonged heating of a scrap of magnetite in a cavity on charcoal (or on a carbon-zirconia compost) before the reducing flame of a blowpipe, then quickly turning out on an anvil and instantly striking. If he happens to have heard of some experiments made about 50 years ago he may now study the metallurgy of the more refractory metals and the alloy steels in a similarly minute fashion; an angular and compact fragment of the oxide, or of intimately associated oxides, being placed at the closed end of a minute "test tube" made of a refractory earth, like zirconia, or the test tube may be made of the oxide of the metal to be reduced; for example of chromic oxide when the enclosure, to be reduced and flattened is also chromic oxide.

Hydrogen, alone or mixed with marsh-gas, is now led into the test tube and the closed end is heated intensely by a warm blast oxyhydrogen blowpipe Reduction of the enclosed fragment takes place slowly and when judged complete, the test tube is quickly laid on the anvil (the flow of hydrogen being maintained), and instantly struck; the compacted plate of metal being now freed from the wreckage of the tube

We heartily congratulate Mr. R. E. Neale, the compiler; also Sir Robert Hadfield, who has supplied technical matter, a thoughtful foreword, and has otherwise helped. Their labours present us with that which is so seldom seen, a really valuable small book on a great subject; a book which may be studied with advantage by all engaged in the iron industry from the most experienced ironmaster to the lad who has just entered a village smithy as a blower.

Erratum.—In the paper of Major Percy A MacMahon, R.A., F.R.S, "The Design of Repeating Patterns for Decorative Work," *Journal*, plate IV., Vol. LXX., page 577,

for  substitute 

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FRIDAY, SEPTEMBER 1, 1922.

***All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.* (2)**

NOTICE.

INDIAN SECTION COMMITTEE.

The Council have appointed Sir George Stapylton Barnes, K.C.B., K.C.S.I., a member of the Indian Section Committee.

PROCEEDINGS OF THE SOCIETY

INDIAN SECTION.

FRIDAY, JUNE 23RD, 1922.

LORD LAMINGTON, G.C.M.G., G.C.I.E., Governor of Bombay, 1903-7, in the chair.

The Paper read was: —

IRRIGATION ENTERPRISE IN INDIA.

BY F. W. WOODS, C.I.E.,

Late Chief Engineer, Irrigation Department, Punjab

The total area of the British Provinces in India and Burma (*i.e.*, to say, of territory directly administered by British agency) amounts to about 625 million acres, or more than twelve times the gross area of Great Britain.

Of this area little more than one-third, *i.e.*, about 223 million acres, is cultivated and sown annually; whilst little more than one-fifth of the cultivated area is artificially irrigated. The remaining four-fifths of the cultivated area is dependent upon rainfall for its germination and maturity. If in any season, in any locality, the rainfall be deficient, the crops fail and the local population suffers distress; whilst a succession of two or more seasons of drought results in famine.

Of the gross area of 49 million acres, which is irrigated artificially, about two-thirds, or over 30 million acres, are irrigated by means of canals or reservoirs (tanks); the rest being irrigated with water drawn from wells, or by other miscellaneous methods. The canal systems of irrigation are mostly administered by official agency, and they irrigate annually more than 20 million acres.

2. Of the area irrigated by canals, about half, or about 10 million acres, lies in the Punjab Province; about one-sixth in the Sind portion of the Bombay Presidency; about one-eighth in Madras, and another eighth in the United Provinces; and one-tenth in Behar and Orissa. From an irrigation point of view, the Punjab is the most important Province in India, and it is there that canal-irrigation, and especially perennial irrigation, has exhibited some of its most striking successes—both scientific and financial. It is as one who has controlled the canal administration of the Punjab quite recently, for several years, that I venture to address my present audience.

3. The Punjab Perennial Canals have proved to be most remunerative undertakings. The capital expenditure on them, down to the end of the year 1919-20, amounted to nearly £16,000,000; and the gross revenue derived from their operations amounted, in that year, to nearly £3,300,000; the net revenue to the State, after deduction of working expenses (£800,000), amounting to nearly £2,500,000; or to, say, 16 per cent. per annum on the capital expenditure. The annual interest charges on capital amounted to £488,000; and when we have deducted these charges from the net revenue, we find there is still left to the Government a net profit of 12½ per cent. on the total capital cost of these works.

Figures like these are calculated to fire the imagination of officials, and even of non-officials, in the agriculturally less-prosperous provinces of India; and it seems to be the case, unfortunately, that a contemplation of the successful results of Punjab Irrigation enterprise has led to a degree of excessive optimism, in an adjacent province, which it is my desire to moderate, if possible, by the considerations set forth in the present discourse.

4. The conditions of perennial irrigation enterprise in the Punjab are at present extremely satisfactory; but it is well to bear in mind that they were not always so; for it would be a grievous mistake to suppose that any kind of project of perennial irrigation—prepared without the engineering skill, and the prudence of agricultural and financial forecast, which have been the outcome of slow evolution and experience in the Punjab—is bound to prove successful, without regard to considerations of geodesy, or of hydrography, or of hydraulics, or to any consideration but that of meteorology in a country of scanty rainfall.

5. British enterprise in the development of irrigation in India began with the restoration of the Western Jumna Canal in the year 1820. Previously there had been a canal which had been constructed by the Emperor Firoz Shah, of Delhi, in the middle of the 14th century. It ceased to flow after an existence of about 50 years, but was restored about the middle of the 16th century by the Emperor Akbar, and was improved further, about the middle of the 17th century, by the Emperor Shah Jahan. It fell into ruin or disuse a century later, and was once more restored in 1820 by the British Government, who, however, made no alterations in the alignments, or noteworthy improvements in the design of the canal system.

6. From 1820 onwards, the tracts watered by the canal experienced alternately, from time to time, visitations of famine in years of scanty rainfall, and of epidemic malaria in "wet" years; and it is noteworthy that the abundance of water supply in wet years was as disastrous to agriculture as the shortage thereof in years of drought—quite apart from considerations of human morbidity or mortality.

The restored canal was about 20 years old when it gave rise to terrible epidemics of fever, in the years 1841 and 1843; one result of which was that the Government was obliged to abandon the military cantonments of Karnal (midway down the course of the canal) by reason of the severe mortality amongst its troops there. The depth of water in the canal, which had been four feet in 1920, had increased to five feet in the year 1830, and to seven feet in the year 1835. By the year 1870, it had increased to ten feet.

The Government appointed a Commission to enquire into the causes of the epidemics, and the Commission (presided over by Major Baker, R.E.) submitted its Report in 1847.

A few years later, in 1856, another severe epidemic of malaria broke out, and we find the Gazetteer recording:—

"In 1856 the people of many of the worst villages abandoned their homes and fled to Jind; and Mr. Sherer, Magistrate of Aligarh, was appointed to inspect the tract. His admirable report was submitted in 1857. He showed that the water level (in the wells) had been raised by the canal from some 60 feet to, in many places, two or three feet only from ground surface; that the fertility of the soil had been very generally diminished, and that the evil had not nearly reached its limits, but must necessarily continue to spread almost indefinitely."

In Mr. Sherer's Report we find:—

"The evil, although developed in different ways, arises from one cause. This cause is the rising of the springs, throughout the tracts affected, to within a very short distance of the surface of the soil."

This was written in the year 1857. Ten years later another epidemic occurred, and General Strachey, Inspector-General of Irrigation in India, wrote:—

"The portion of the canal near Karnal is a disgrace to our administration, and has been for many years past. It creates most pestilential swamps, which must be got rid of unless we are content to perpetuate this abominable nuisance, which has been talked about for the last 25 years, during which no serious attempt has been made to abate it."

Dr. Adam Taylor was appointed to investigate and report on the problem, and made his Report in 1868.

7. The general result of all these discussions of the waterlogging problem was that, in the years 1871 and 1874, 50 years after the restoration of the old *Badshahi* Canal, the Secretary of State for India sanctioned estimates, amounting to over one crore of rupees (£1,000,000 at the then rate of exchange) of the probable cost of re-aligning and re-modelling the Western Jumna Canal. A very extensive system of surface drains was also included in the project, which was carried out to completion by the year 1885.

This expenditure had the effect of reducing the net revenue from 37½ per cent. per

annum on capital cost to 5½ per cent. per annum, and the consent of the Government to this reduction of net profits was an index of its realisation of the gravity of the waterlogging evil.

In the year 1889, also, the Secretary of State for India sanctioned a project for the construction of a new branch of the Canal, extending from above Karnal, to Sirsa, a distance of 140 miles, thereby greatly increasing the area over which the water of the canal was dispersed in irrigation, and reducing the intensity of irrigation per unit of the gross area commanded.

8. The result of these measures has been excellent. The area irrigated annually by the Canal, which averaged about 400,000 acres during the period 1860-1880, and which dwindled to less than 300,000 acres a few years later, now averages about 750,000 acres annually.

This irrigation, however, of 750,000 acres, is dispersed over a gross area of 2,700,000 acres; and the cure of the waterlogging evil in the Western Jumna Canal tracts has synchronised with the reduction of the intensity of irrigation to 28 per cent. of the gross area annually, or to 12½ per cent. of the same in the winter season only.

9. Irrigation canal science was still backward, and the Punjab Canals were still in trouble during the last decade of the 19th century, from various causes. The Sirhind Canal was opened for irrigation in the year 1882, but suffered seriously from deposits of water-borne sand, which accumulated in shoals to such a height that by the year 1893 the question of closing the canal for three months annually during the silting season, was seriously mooted and agreed to. Later on a remedy was found for this shoaling trouble; but not till the year 1901. Meanwhile, the Bari Doab Canal, which had been opened for irrigation in the year, 1859, experienced the waterlogging trouble in its upper reaches; so that in the year 1892, winter, or *rabi*, irrigation from it was discontinued in the District of Gurdaspur and part of Amritsar. This trouble is still in being, and is very much in evidence in years of abundant rainfall. Around the city of Amritsar the groundwater lies at a level only about 5 feet below ground surface at ordinary times, and heavy rainfall brings it up to the surface.

In 1887, the (Lower) Chenab Canal was opened for irrigation; but proved a failure by reason of defective design. It had been designed to draw water perennially from the River Chenab without the help of a regulating weir across the river; but the design was defective for that purpose, and silt-deposits put the canal out of action in the autumn. A weir was built across the river at its head in the year 1892, and the scope of the canal system was vastly increased and brought into effect by the year 1902; since when the history of the canal has been an uninterrupted record of financial success.

10. The year, 1901, 81 years from the inception of British irrigation enterprise in India, marks the date from which the success of all the perennial canals of the Punjab has been fully assured; but the troubles and difficulties through which that enterprise has forced its way ought not to be overlooked in any new schemes that may be devised now or hereafter. These canals have been commercially successful because they were designed with caution, in the light of agricultural and financial considerations, as well as from the point of view of engineering construction; but failure may yet overwhelm any projects, apparently similar at first sight, but essentially different in underlying conditions, if such projects be conceived in a spirit of undue optimism, or in ignorance of the essentials requisite to success in such undertakings. The lessons inculcated by practical experience of irrigation works in the past, especially as regards the risk of waterlogging of the soil, and of silt-trouble in canals, must be intelligently applied to the designs of future irrigation projects, if results as successful in the future, as those of the past, are to be reckoned upon.

11. The great rivers of Northern India, the Ganges and the Indus, and their tributaries, the Jumna, and the five rivers of the Punjab, at the points where they issue from the Himalayan Mountains, on to the alluvial plains, discharge volumes of water varying from 2,000 to 10,000 cubic feet per second in the winter, or low water, season, up to from 30,000 to 450,000 cubic feet per second ordinarily in the summer, or flood season; whilst extraordinary floods of short duration, due to heavy rainfall, occasionally raise the discharges up to from 200,000 to 1,000,000 cubic feet per second.

12. THE SUB-MONTANE ZONE.

At the points where these rivers issue from the Himalayas, the ground surface

of the plains usually slopes away from the hills at the rate of from 10 to 25 feet per mile. Floods of such magnitude, flowing with velocities generated by such steep gradients, have an erosive force far greater than any soil but rock can withstand ; hence, in the sub-montane regions, the currents of the rivers erode their channel-soil in the vertical as well as in the horizontal planes ; and boulders, in all sizes, from shingle up to stones several feet in diameter, forming the bed of the stream, indicate the erosive power of the currents. Where the rivers issue from the Hills, they are usually from ¼ to ½-mile wide ; but as they progress down stream, they widen out, by process of lateral erosion, until, at a distance of 50 or 100 miles, or so, downstream, their valleys, formed by erosion, are anything from one to ten miles wide.

13. The Lower Erosive Zone.

At this distance from the Hills, the declivity of each river bed has usually flattened to about 1½ feet per mile, and the boulders and shingle, of the bed-soil further upstream, have given place to coarse-sand and silt formations. In this region, which we may describe as the Lower Erosive Zone, the width of channel or valley eroded by the currents, is far greater than any but the greatest and rarest floods can occupy ; so that, ordinarily, even in the summer, or flood, season, the river occupies only a fraction of the width available for it. It flows in one or more main channels, and usually several subsidiary channels ; with shoals or reed-grown islands between them.

14. If we draw a line at right angles to the course of the river in the Lower Erosive Zone, and survey the ground levels along that line, we find that although the High Flood Level of the river is high enough to submerge the whole of the riverain, or lowlands, in the valley, it is yet well below the levels of the uplands which set lateral limits to the riverain. This is the distinctive feature of the Lower Erosive Zone, to which I particularly draw attention, as bearing on the problem of irrigation. The lowlands are known as *khadir*, or "hidden," in allusion to their liability to be covered with sheets of water, or with dense vegetation, during the flood season. In the Punjab vernacular they are also known as *Hithar*, or lower. The up-lands are known as *bhangar*, or *utar*, the latter word meaning "upland."

15. The Upper Deltaic Zone.

The erosive action of the currents in the Lower Erosive Zone tend to flatten the declivity of the river bed ; so that, as the river progresses downstream, the erosive action decreases, and a tendency to deposit silt and sand by alluvial action becomes more and more pronounced.

The bed of the river, and the level of the riverain land, gradually rise ; and the relative elevation of the uplands diminishes.

In the Punjab this occurs in the region immediately upstream and downstream of the confluences of its rivers with each other and with the Indus ; which region we may describe as the Upper Deltaic Zone. In this zone the river tends to occupy, generally, one main channel, which, by alluvial deposit, raises itself gradually higher ; so that the riverain land, formed by alluvial deposit from the river's floods, becomes a well-defined ridge, with the river located along the top of the ridge, and the ground surface sloping away downwards on both sides, towards low-lying valleys. Under such conditions, it is obvious that there is a considerable possibility of the river's breaching its banks during some high flood, and deserting its elevated channel on the ridge, for another at a lower level in the lateral valley.

16. The Lower Deltaic Zone.

Finally, as the river progresses further down stream, it arrives at the true Deltaic formation, in its approach to the sea. At the head of this "delta" it splits up into two or more channels, each of which, forming for itself an ever more and more elevated ridge of alluvial deposit, flows into the sea by a separate "mouth."

17. River Gradients.

We see, then, that if a section were drawn along the bed of a North Indian river, in the vertical plane, the bed line of the river would appear as a curve, of gradually varying curvature, sharper upstream and flattening out downstream, nearly tangential to the vertical at the upstream end, and near tangential to the horizontal at the downstream end.

18. The canals of Lower Egypt, and of Madras, are examples of irrigation canals in the Lower Deltaic Zone, IV. Those of Middle Egypt, Sind and some of the Punjab Inundation Canals may be classed in the Upper Deltaic Zone, III. ; whilst the

rest of the Punjab Inundation Canals occur in the Lower Erosive Zone, II. The perennial canals of the Punjab and the United Provinces of India offtake from their parent rivers in the Sub-montane and Lower Erosive Zones I. and II.

19. It is well to bear in mind the difference, in natural conditions, of relative elevation of water and of ground surface in Zones IV., III., and in the riverain lands of Zone II., from those of the uplands in Zone II.

In Zone I. it is hardly necessary to raise the water level of a river, even in the low water season, by means of a barrage or weir across the river, in order to ensure a constant supply of water to offtaking canals. It is in Zone II. chiefly that the necessity of raising the water surface of the river, whether in the high-water season or in the low-water season, in order to irrigate the uplands, above the level of the river's highest floods, has been felt, and has led to the construction of the great river weirs of the Punjab and the United Provinces.

In Zones III. and IV., though weirs or barrages may be built across rivers, in order to raise their low-water levels for purposes of irrigation (as has been done in Madras, Behar, and Egypt), such construction is a luxury rather than a necessity; and it depends upon the particular circumstances of each case whether the country can afford the luxury.

20. Punjab Irrigation History since 1901.

It is probable that the high-water mark of irrigation-canal enterprise on the part of British engineers in India was reached by the completion of the Lower Chenab Canal project, in the year 1902, at a cost of about £1,800,000 (270 lakhs of rupees). It was then irrigating annually 1,900,000 acres of land; an area which has since increased to about 2,400,000 acres annually. Its full capacity is nearly 11,000 cubic feet per second (about six times the average discharge of the Thames at Teddington), and it yields a net revenue that represents a return of nearly 45 per cent. per annum on its capital cost.

The completion of this canal was followed by that of the Lower Jhelum Canal, a similar, but much smaller, canal, which yields a net revenue return of more than 20 per cent. per annum of its capital cost.

Next followed the great Triple Canal Project, of greater magnitude and far greater cost, but not nearly so remunerative as the Lower Chenab Canal. The Triple Canal Project was completed in about the year 1916 at a cost of about £6,900,000 (1,033 lakhs of rupees).

When fully developed it is expected to yield a net revenue return of about 8 per cent. per annum on its capital cost.

21. The Sukkur Barrage Irrigation Project (1920).

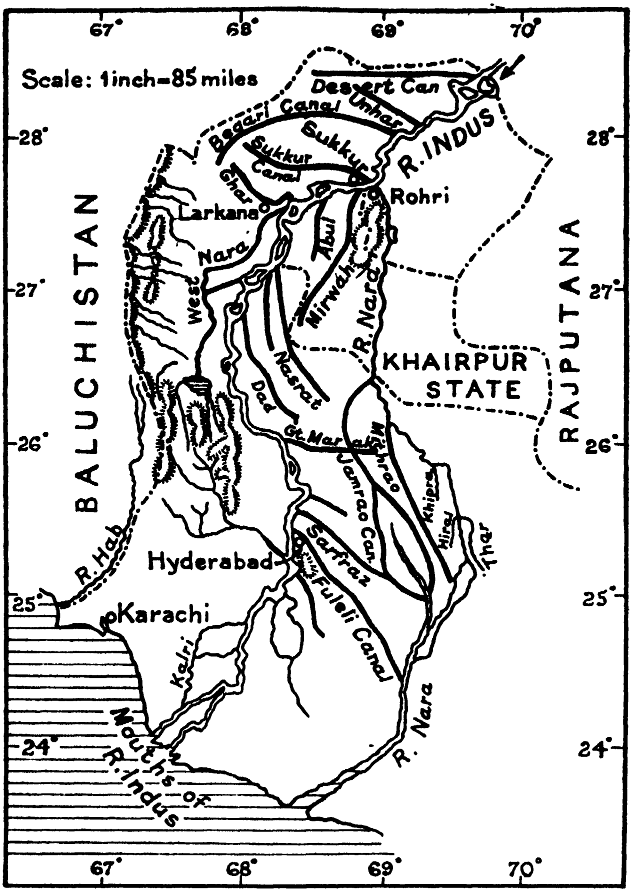
The contemplation of these excellent results has encouraged the engineers and revenue officials of Bombay and Sind to put up a project, known as the Sukkur Barrage Irrigation Project (1920), which, according to its promoters, will easily put all other projects, present or past, whether in or out of India, in the shade, by comparison with its figures of cost, and the vastness of its scope.

My attention was drawn to this project, which has received the approval (subject to compliance with certain financial precautions) of the Secretary of State for India, by perusal of a report of a lecture delivered on the subject a year ago in London by Dr. Summers, C.I.E., the well-known expert irrigation engineer of Sind. So that when I was honoured recently by an invitation to discourse before this distinguished Society on the subject of "Irrigation Enterprise in India," I felt that I could not serve the Indian public and the Government of India better than by criticising the designs and estimates of this important project in the light of experience of perennial irrigation works in the past.

22. Physical Conditions of the Indus Riverain.

The River Indus, from the point where it enters the Province of Sind (see Plate No. 1) 80 miles upstream of the rocky gorge at Sukkur, down to its mouths at the sea-coast about 400 miles downstream of Sukkur, lies along a ridge, alluvially formed by its own deposits of sediment, at an appreciable elevation (about 20 feet) above well-defined valleys, known as the East and West Nara, respectively, which lie, one on either side of it, at distances varying from 5 to 50 miles. These Nara valleys represent what may have at some period in the past been the bed of the river; and it is quite on the cards that the river may at some future period abandon its present elevated ridge and breach its way into one or other of the

PLATE I.



The River Indus and existing Canals of the Province of Sind

lower lying valleys. (See Plate II, Fig. (a)). A brief reflection suffices to show that it is comparatively easy to irrigate from the river, in its high-water season, the greater part of the ridge of fertile soil that has been alluvially formed by the deposits of silt from its own floods in the past. And we find, as a matter of fact, that such irrigation has been practised in the past, from time immemorial, by the primitive devices of the local population; long before the British occupation of the country introduced some more scientific methods into their design, construction and control. The gross area of land thus commanded by existing irrigation canals in Sind amounts to nearly 18,000,000 acres; of which, it is reckoned, nearly 11 million acres represent culturable soil.

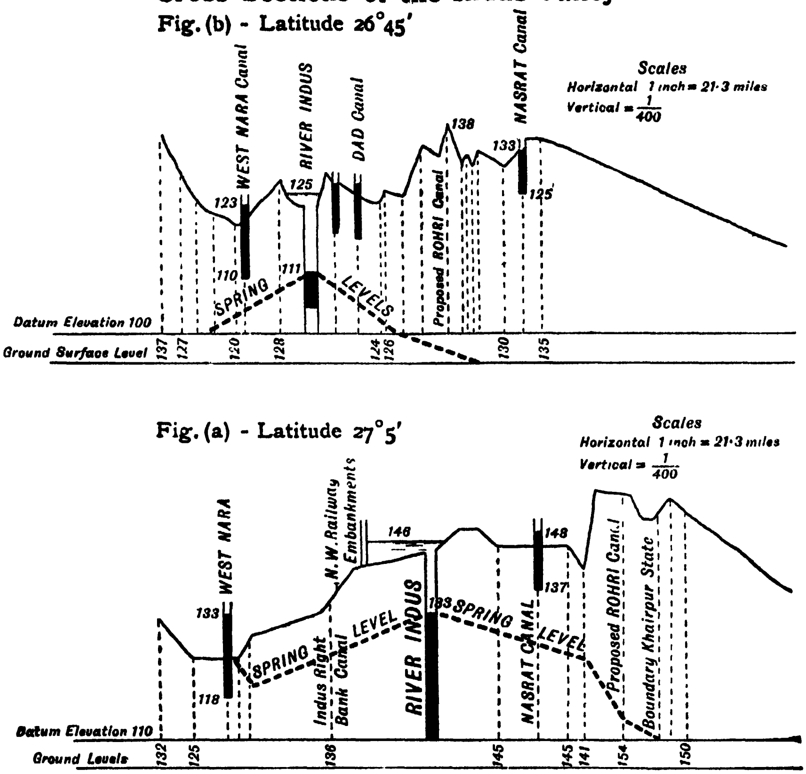
The area irrigated annually by the existing inundation canals of Sind amounts to about 3 million acres; or about, 27 per cent. of the estimated culturable area of the Province, and it is natural and intelligible that the Bombay officials should wish to double or treble, if possible, the area irrigated annually. But it is equally intelligible that their lack of experience of perennial canal irrigation may hide from their minds the natural limitations to any very great increase of intensity of perennial irrigation, in the peculiar alluvial formation to which I have drawn attention.

23. Outlines of the Sukkur Project (1920).

The Sukkur Barrage Irrigation Project provides for the construction of a barrage, or bridge-way fitted with sluice gates, across the River Indus at Sukkur, capable of holding up the water of the river to a level of 194.5 feet above the mean sea-level at

PLATE II

Cross-Sections of the Indus Valley



Karachi, for the purpose of irrigating the whole of the land on either side of the river, from Sukkur down to the town of Hyderabad. The gross area of land thus commanded by flow is estimated to amount to about 7½ million acres.

The Sukkur Barrage Project aims at irrigating annually an area of 5,300,000 acres; rather more than the total culturable area of Upper and Lower Egypt combined; more than double the area irrigated annually by the Lower Chenab Canal, and nearly treble that of the Triple Canal Project. The estimated cost of the Sukkur Barrage Project is 1,842 lakhs of rupees (about £12,300,000); which is nearly seven times the actual cost of the Lower Chenab Canal, and nearly double the actual cost of the Great Triple Canal Project of the Punjab.

These data will suffice to give a fair idea of the magnitude of the Sukkur Barrage Irrigation Project.

The Report on the Project impresses me as being the work of a junior engineer of more than average industry, zeal, and ability. But no amount of natural ability on the part of an engineer can make up for a lack of practical experience of perennial canal irrigation in the preparation of the designs, estimates, and financial forecasts of by far the greatest scheme of perennial canal irrigation that has hitherto been seriously put up for approval.

24. Comparison Between Upper Sind and Middle Egypt.

The River Indus and the Province of Sind have many points of resemblance, in physical characteristics, meteorology, etc., with the River Nile and Egypt.

Sind, like Egypt, is remarkable for the scantiness of its rainfall. The climate of Sind is much hotter than that of Egypt, but the rainfall of the latter country is even scantier than that of the former.

The Indus, from Sukkur to Hyderabad, a distance of 240 miles, resembles the Nile in Middle Egypt from Assiut to, say, Cairo (235 miles), in that it flows on an elevated ridge formed of its own alluvial deposits by spill; and in that it is flanked by lateral valleys at a lower level than its own marginal land.

PLATE III

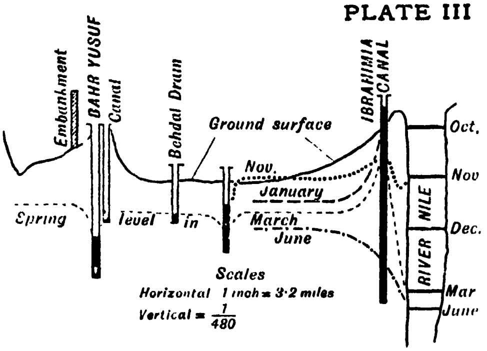


Fig. (c) Cross-Section of Nile Valley at Minia (1908)

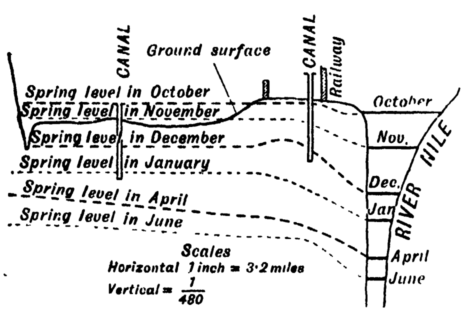


Fig. (d) Cross-Section of Nile Valley at Girga (1908)

And downstream of Hyderabad, down to the sea-coast, the Indus has the physical characteristics of the Nile in Lower Egypt.

There is in Middle Egypt an ancient channel, the Bahr Yusuf, which probably represents a former channel of the Nile, long since abandoned. The Bahr Yusuf runs roughly parallel to the Nile, at a distance of about five miles, but at a level (see Plate III., Fig (c)) which enables it to act as a drain, and it has a separate outfall at a low level, into the depression known as El Fayum. Similarly, in Sind there is an ancient natural channel, the Narra (or East Nara), roughly parallel to the Indus, at a distance of about 50 miles from it, but at a level roughly 20 feet lower.

25. The Narra River.

The Narra may represent a former channel of the River Indus; or it may even represent the long-lost *sixth* river of what is *now* known as the Punjab (Five Waters), but which might formerly have been called the "Chhe-n-ab" (Six Waters). The five existing rivers of the Punjab, viz., the Jehlam, the Chenab (Chhenab ?), the Ravi, the Bias, and the Sutlej, are known, in the reach below their final confluence, where they are united in a single stream, as the *Punjnad* (Five Streams)—a word synonymous with *Punjab.* The perished River Narra (Nurra, or Nara), is known also in Sind as *Hukkra*; a name which is also applied in the Punjab to the "lost" river, which can be traced upstream (see Plate* IV.), through the deserts of Bahawalpur and Bikanir, to Hissar and the Nardak; where it may be identified with the Ghuggur, Chitang, and Saraswati, flowing from the direction of Thanesur—the sacred shrine of Kurukshetra, second only in sanctity to Hardwar, on the Ganges. It is conceivable, even, that the River Jumna flowed, at some remote period in the past, into the Indian Ocean, *via* the alignment indicated by the existing Saraswati, Hukkra or Narra, Channels, thus forming the *sixth* river of the Chhenab (now Punjab), before it, as the result of some extraordinary natural avulsion, turned away to the left and joined the Ganges to flow into the Bay of Bengal.

However this may be, the position of the Narra channel, relatively to that of the Indus, corresponds to that of the Bahr Yusuf relatively to that of the Nile in Upper Egypt. With this noticeable difference, however, that the practice, continued for centuries past, of "basin" irrigation in the Nile Valley, has had the effect of silting up the valley between the Nile and the Bahr Yusuf; whereas no such action has occurred between the Indus and the Narra.

26. Comparison of the Indus with the Nile.

The *average monthly* discharge of the Nile at Assiut ranges from a minimum of 21,000 cusecs in May up to a maximum of 325,000 cusecs in September; whilst the average yearly discharge is 107,000 cusecs.

The *average monthly* discharge of the Indus at Sukkur ranges from a minimum of about 20,000 cusecs in January-February, up to a maximum of 460,000 cusecs in August; whilst the average yearly discharge is 107,000 cusecs—the same as that of the Nile.

These figures indicate that the flood season flow of the Nile, though much less at its *maximum*, is more sustained, stately, and useful for irrigation than that of the

* Not reproduced.

Indus; which latter, with its more rapid transitions in magnitude of discharge, is more turbulent, unruly, erosive, and liable to change its course by sudden natural avulsion.

The ratio by volume, of the water-borne sediment of the Nile to the water bearing it, is, on the average of the whole year, $\frac{1}{1200}$ and in the months of August and September about $\frac{1}{530}$

The corresponding figures for the Indus are, on the average of the whole year, $\frac{1}{500}$ and in the month of August, $\frac{1}{400}$

These figures indicate more erosive currents in the Indus than in the Nile; and it is probable, at the same time, that the silt of the Indus is more sandy and less clayey—less fertile in fact—than that of the Nile.

27. Official Experts Silent on the Subject of Waterlogging.

The subject of waterlogging has received scant attention from those responsible for the Sukkur Project (1920).

Almost the only reference to subsoil water levels in the Project report is the following reference to the Rohri Canal tract:—

"Very little irrigation from wells is practised, owing to great depth of subsoil water below ground level. Near the river this depth varies from 20 to 30 feet below ground. In the Jamrao tract it is from 20 to 35 feet; in Fuleli and Hyderabad from 30 to 50 feet. In Nasrat Canals district, except along the river banks, it is from 40 to 65 feet below ground."

The higher official authorities seem to have been vague in their ideas on the subject. There was a conference of high officials held at Karachi on the 19th January, 1918, and at that conference, Sir Thomas Ward, Inspector-General of Irrigation in India, spoke as follows:—

"The (estimated) duty (of the water) must also be considered from the point of view of waterlogging. It is not possible, however, for me to give an opinion on this question. This must be left to people who know Sind conditions."

This left the responsibility with the Bombay-Sind officials. Another conference of officials was held at Government House, Karachi, on the 3rd February, 1919, under the presidency of the Commissioner. In the minutes of that conference the following is recorded:—

"Mr. Gebbie (Chief Engineer, Irrigation Works, Bombay) raises two points:—

"(a) Danger of waterlogging.

"(b) Minimum discharge of the River Indus."

The conference then proceeded to discuss other matters, but avoided the subject of waterlogging. Whence it would appear that the Government of India is still without expert advice on this important problem.

28. The Sukkur Barrage Project (1920).

The River Indus in Upper Sind, as we have seen, flows on an elevated edge of soft alluvial soil, formed by deposits of silt from its own flood-spills. Buckley, in his excellent treatise, "The Irrigation Works of India," gives the following description:—

"Sind is an alluvial plain, almost every part of which has been swept by the Indus at some time or other. Traces of ancient channels are to be met with in every direction. The river has gradually worked its way from west to east. . . . The river more or less continually carries away its banks in one direction, and forms new land in another."

From time to time, during the past 70 years, projects for the control of the River Indus, for irrigation purposes, by means of a weir or barrage built across the river at Sukkur, have been mooted, considered, and rejected as unsatisfactory. All experts who have dealt with these projects in the past have been keenly apprehensive of the risk of the river's changing its course, and deserting the Sukkur gorge altogether as a consequence of any artificial obstruction offered to the river's flow there. The latest and best considered project was one prepared in the year 1911. In this project, which was, however, ultimately negatived, on the advice of a committee of experts whom the Secretary of State for India consulted for the purpose, the site proposed for the barrage was at Bhakkar, just upstream of the rocky gorge of Sukkur.

With a view of minimising obstruction to the river's flow, the level of the top of the gates of this barrage was fixed at 192 feet above mean sea-level at Karachi.

29. **The Sukkur Barrage Project (1920).**

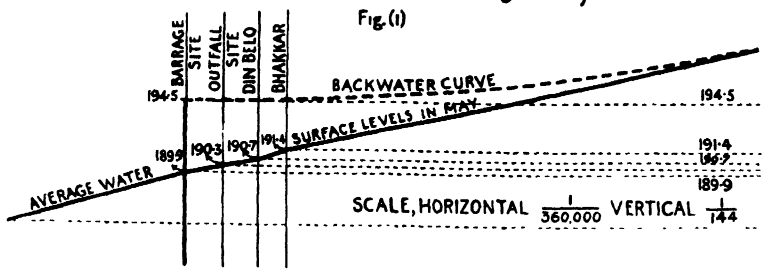
The authors of the Project of 1920 have been bolder (or rasher, as the case may be) than their predecessors. They propose to build the barrage at a site downstream of the gorge—about 3 miles downstream of the 1910 site—and to have the top of the gates at 194.5 feet above sea-level. They claim that the effect of the obstruction offered by the barrage to the flow of the river will not extend further upstream than the gorge; and that as the river is contained securely in high ground, between the gorge and the barrage-site, there can be no risk of the river abandoning its present channel by reason of interference with its flow through the barrage.

The River Indus at Sukkur

PLATE VI.

Probable Backwater Effect of Barrage in May

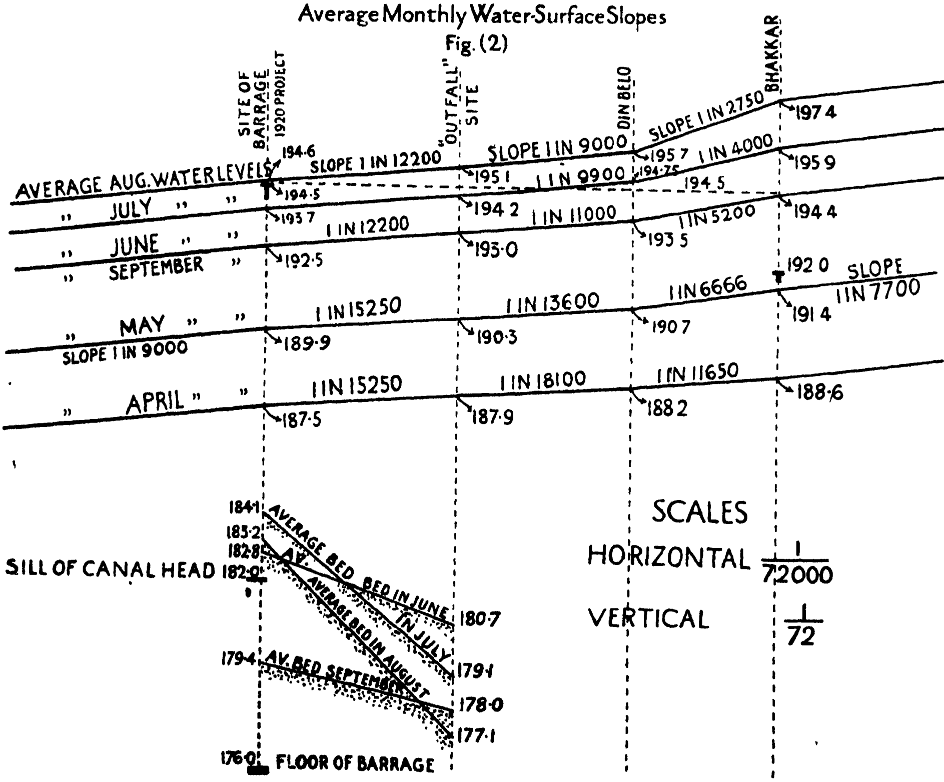
Fig. (1)



The River Indus at Sukkur

Average Monthly Water-Surface Slopes

Fig. (2)



In this belief they are mistaken. They appear to have been associating afflux with the maximum flood only. But Plate VI, Fig. 1, shows that the effect of ponding-up to 194.5 at the barrage in the month of May

will extend 16 miles up-stream of the barrage, and 13 miles up-stream of the gorge. This will cause shoaling up-stream of the gorge, which will obviously increase the risk of river-avulsion. See also, Plate VI, Fig. 2. The Barrage of the 1920 Project will interfere with and obstruct the flow of the river throughout the flood season, except in the month of August. The authors of the 1920 project have probably been driven to this risky expedient as a consequence of their decision to include in the scope of their project the irrigation at present effected from the canals on the right bank of the river at, and below, Sukkur.

The water surface of the river *at Bhakkar* is, throughout the four months, June to September, at, or above, the level 194.5, *on the average*; and the authors of the 1920 Project may have felt that they could not very well claim to be improving the condition of these canals, by means of the Barrage, unless they were able to claim that they would thereby be enabled to hold up the water to that level at all times, by means of the gates.

The fact that by holding up the river to the greatest practicable height they were able, at the same time, to *increase* (on paper) *the area* brought under flow by the North West Canal, as well as to *decrease the cost*, by reducing the depth of excavation, of all the canals, no doubt helped to decide them to adopt that feature of design.

The mean annual discharge of the Indus at Sukkur, is about the same as that of the Nile at Aswan; but the mean monthly discharge of the former river, is about 33 per cent. greater, at the height of the flood season, than that of the latter river. The Indus is, moreover, a more turbulent, and badly-behaved river, than the Nile.

The barrage across the Nile at Assiut has a waterway 1,832 feet wide; and it is designed to discharge the maximum flood under an afflux of five feet. The authors of the Sukkur Barrage Project (1920), in their endeavour to pass the maximum flood of the Indus (assumed to be 1,500,000 cusecs) with an afflux not exceeding one foot, have designed their Barrage with a waterway 3,960 feet wide, and floor at 176 feet above mean sea-level. With this ample waterway they hope to escape the risk of the river changing its course, and deserting the Barrage on account of the obstruction to flow offered by it. But in dodging the Scylla of excessive afflux, they have drifted into the Charybdis of silt-trouble; which, in the end, will necessitate the creation of the excessive afflux which they have sought to obviate.

30. Hydraulic Data of the Indus near Sukkur.

In the Sukkur Project (1920), the Barrage is located about three miles downstream of the rocky gorge at which the Barrage of the 1911 Project was located; and about one mile downstream of the site known as the "Outfall," where accurate observations and studies of the river's hydraulics have been carried on weekly by the local engineers throughout the past 20 years, on the advice of the Indian Irrigation Commission of 1901. I cannot praise too highly the wise forethought of the Commission in giving that advice, or the labours of the engineers who have carried it out, and thereby given us a knowledge of local conditions which is of the highest utility.

The four months, June, July, August and September, are the months in which the water of the Indus carries its heaviest charge of silt in suspension; and they are also the months in which practically the whole of the irrigation of Sind is carried out under existing conditions.

The hydraulic conditions of the Indus, *at the Outfall site*, during these months, are as shown below :—

TABLE I.

Month.	Mean Monthly Water Level.	Mean Bed Level	Highest Mean Monthly Bed.	Lowest Mean Monthly Water Level.	Discharge (Cusecs).	Monthly Mean Velocity (feet per second).
June ..	193.1	180.7	183.7	191.8	230,000	5.6
July ..	194.1	179.1	181.6	192.8	310,000	5.9
August ..	196.0	177.2	179.7	193.8	460,000	7.2
September ..	193.6	177.0	180.8	191.1	266,000	5.4
Mean Averages	194.2	178.5	181.5	192.4	316,000	5.8

From statistics recorded by the Indus River Commission, it appears that the fall of water surface of the river, during these months, from the "Outfall" site to that of the *proposed Barrage*—a distance of 6,100 feet—is as follows :—

June—0.55 foot; July—0.62; August—0.65; September—0.43. Average 0.56, or, say, half a foot.

31. Levels of the Indus at the 1920 Barrage Site.

From the Report on the Project, it appears that the site of the proposed Barrage is that of a natural bar in the river bed, or of a shoal formed by material scooped out of the river bed upstream, by the currents rushing through the gorge, and deposited at that site ; and that *the river bed is higher at the Barrage Site than at the Outfall Site,* 6,100 *feet upstream.*

The following Table is furnished to show what the bed levels were at the Outfall and at the Barrage Site on certain dates :—

32. Design of the Barrage (1920).

The authors of the Sukkur Project (1920), in order to give this Barrage ample waterway, put its floor level so low as 176.0; and with a view to excluding sandy sediment from the canal they designed the canal head with a masonry sill at 182.0, that is, 6 feet higher than the floor of the Barrage. They also provided in the design for moveable gate-cills, capable of rising, from behind

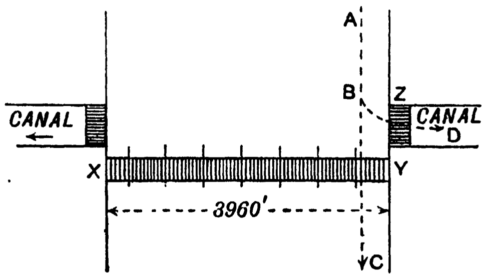


Fig. (3) Plan of Sukkur Barrage across River Indus

TABLE II.

Date.	Discharge.	Bed Level at at Outfall.	Bed Level at Barrage Site.	Rise.
31-7-18	261,000	177.89	180.28	2.39
17-7-18	403,000	174.61	180.17	5.56

From these data we may infer that the rise of bed level from the Outfall to the Barrage Site corresponding to other discharges would be for :—230,000 cusecs, 2.1 feet ; 310,000 cusecs, 5 feet ; 460,000, 6 feet. Whence we may deduce the hydraulic conditions at the Barrage Site, corresponding to those given in Table I. above, to be as follows :—

the masonry cill, to levels higher than 182 ; but these cannot come into action till the river water level rises appreciably above 194.0.

Now let us consider the conditions that will prevail at the site of the Barrage, and of the Rohri Canal Head, in the month of July and August. The plan of the locality will be as shown in Fig. (3) above.

TABLE III.

Month.	Mean Monthly Water Level.	Mean Monthly Bed Level.	Discharge.	Mean Velocity.
June ..	192.55	182.8	230,000	5.0
July ..	193.48	184.1	310,000	7.0
August ..	195.35	183.2	460,000	8.0
September ..	193.17	179.4	266,000	4.0
Mean Averages	193.6	182.4	316,000	6.0

Let X Y (Fig. (3) above,) represent the barrage in plan, and Y Z the Head Regulator of the Rohri Canal. Consider the current of the river flowing through the Barrage along the line A B C, and through the Canal Head along the line A B D. A section in the vertical plane, along the line A B C, will be as shown in Fig. (4) below :—

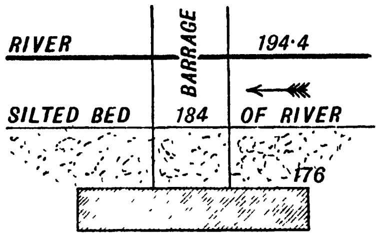


Fig. (4) Section through Barrage on line of flow (1920 Project)

Consider the average conditions of the months July-August. The mean level of the sandy bed of the river is 183.7, and of water-surface 194.4. The sand is lying 8 feet deep over the floor of the Barrage. The waterway being ample, there is practically no afflux at the Barrage ; and therefore no force of current capable of scouring the sand down to floor-level 176.0.

Next consider a vertical section along the line A B D (Fig. 5).

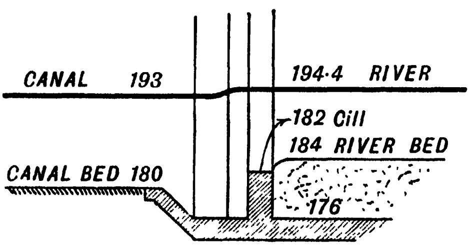


Fig. (5) Section through Canal-Head on line of flow (1920 Project)

The *sandy bed of the river is nearly two feet higher than the masonry cill of the canal head*, and it is obvious that the current of entry will sweep large quantities of coarse bed sand from river into canal.

The movable gate-cill, behind the masonry cill, cannot be brought into action unless the river water surface is ponded up appreciably above 194.0 by the Barrage gates ; and this will mean obstruction to the river's flow, and shoaling of river bed upstream. I calculate that the river water surface would have to be ponded up at least 4 feet, to level 198.5, in order to scour the river bed down to level of Barrage floor, 176.0, and that the "backwater" caused by ponding-up would extend upstream to a distance of about 16 miles. In the conditions illustrated above what becomes of the "raised" masonry cill at 182 ? It is *submerged in the river sand ; not raised above it !*

33. Design of Rohri Canal Head (1920 Project).

Again, consider the current of entry into canal head. It may be regarded as in uniform flow, in 10 open channels of masonry, 25 feet wide and 11 feet deep.

$$\text{Discharge per channel} \frac{11{,}000}{10} = 1100 \text{ cusecs.}$$

Mean velocity, 4 feet-seconds; Kennedy's

$$\text{Critical Velocity Ratio} = \frac{4.0}{3.9} = 1.03\ V_0.$$

Whereas the corresponding ratio for the canal, with Kutter's N = 0.025, would be 0.62 V_0 only ; and the canal current, with 2.86 velocity, could not carry on the sand that would be brought into the canal with a current of velocity 4 feet per second.

Throughout the months of June, July and August, the sandy bed of the river will be at a level higher than the masonry cill of the canal head, and the canal is bound to silt heavily.

I have shown, in Appendix D., that if the value of Kutter's coefficient of rugosity in the canal should prove to be, as it is likely to be, 0.025 or higher, the water depth required in the canal will be 14.3 feet, or more ; implying a water surface level in canal of 194.3, and in river 195.0. If silt be deposited in the canal, higher water levels than 194.3 will be required in the canal in order to discharge 10,992 cusecs. Efforts to keep the sandy bed of the river scoured down to level 176.0 may require ponding up of the river water surface to 199, or even 200. And this will be going on throughout the greater part of the months of June, July and August!

During these months the fall of water surface from upstream of the Sukkur gorge down to the Barrage Site is usually about 2.5 feet ; but if the water surface of the river is held up five or six feet, at the Barrage Site (say, from normal 192.5 or 195.5 up to 199.5) for purpose of scouring river bed in front of canal head, *the fall of water surface between Sukkur and the Barrage Site will be drowned out*, through the greater

part of the months when the river currents are most heavily silt-charged; shoaling will be encouraged upstream of the gorge, and the risk of an avulsion of the river from its present course will be greatly increased.

The water surface slope of the river at the Barrage Site, in the months of June, July and August is about 1 in 10,000. That of the canal is designed to be much flatter, viz., 1 in 15,600. In the absence of any effective method of silt control at canal head, the canal is sure to get silted up.

34. The Barrage Will Disturb the River's Regime.

The very amplitude of waterway provided for the barrage by the authors of the Sukkur Project (1920), though it will minimise the afflux caused by the barrage to *very great floods*, will aggravate silt trouble at canal-head, and necessitate a practice of continuous ponding-up of river flow throughout the monsoon season generally, which may eventuate in disaster. The entire design of the barrage, canal heads and canal head reaches, as presented in the 1920 Project, needs re-casting. *The full supply level of the canal must be lowered several feet below the* 193.0 *level fixed in the* 1920 *Project design*. This will not safeguard it from its liability to suffer from shoaling; but it will afford a margin of command, between river and canal, which may enable water to be passed into the canal over the shoal of sand deposited on its bed.

35. Ratio of Winter to Summer Irrigated Areas.

The authors of the Sukkur Project (1920), have designed their canals on the hypothesis that the area irrigated in the winter will be double that of the summer. By this means they are able to keep down the cost (on paper) of their project. But there is no justification, in past experience, for such a forecast of irrigation in land of deltaic formation; the physical conditions of the Indus Valley in Sind being similar to those of the Nile in Egypt, and of the canals in Madras and Behar in India.

36. Inadequate Utilisation of Silt-Laden Water.

By designing on the basis of a winter irrigation twice as great as the summer irrigation, the authors of the Sukkur Project (1920) refrain from utilising as much as they might of the abundant summer flow of the Indus, with its rich burden of fertilising silt, and exhaust the scanty flow of the river in the winter, when it carries little or no silt.

37. Other Claims to a Share of the Winter Flow of the Indus.

The winter flow of the Indus, at Sukkur, in the months of January and February is usually only about 30,000 cusecs; whilst in years of scanty flow it diminishes to about 20,000 only.

The perennial canals of the Sukkur Project (1920) have been designed with an aggregate capacity of 30,000 cusecs; so that they can take the whole of the winter flow of the Indus. But the area comprised within the scope of this Project is only 7,500,000 acres, gross; and, say, 6,000,000 acres, culturable. The gross area of Sind is, however, 18,000,000 acres, of which 11,000,000 are reckoned to be culturable, and available for irrigation. The remaining 5,000,000 acres of culturable soil in Sind, not provided for in the Project, are just as much entitled to a share of the winter flow of the Indus as the Project area; so the Project cannot be right in monopolising the winter flow as proposed.

Moreover, there are the claims of the Punjab to be considered. There is a tract of some five million acres of land lying on the left bank of the Indus, between it and the Jhelum and Chenab Rivers, the irrigation of which has been under consideration by the Punjab Government for 20 years past.

The mere fact that the Thal has vested rights in the winter flow of the Indus, superior to those of lands in Sind, further down the same river, further emphasises the unwisdom of designing the Sukkur Project canals to irrigate with a greater volume of winter flow than is absolutely necessary from the point of view of irrigation science and agriculture.

(*To be concluded.*)

Production of Turpentine and Rosin in Greece.—A note from the Greek Minister of National Economy (reported by the United States Consul-General at Athens) states that the collection of rosin from trees begins in Greece in May and lasts until September. The distilleries operate from June to March or April. The annual production of colophonium is about 4,000 tons, and of turpentine, 1,000 tons.

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FRIDAY, SEPTEMBER 8, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY

INDIAN SECTION.

FRIDAY, JUNE 23RD, 1922.

IRRIGATION ENTERPRISE IN INDIA.

BY F. W. WOODS, C.I.E.,

Late Chief Engineer, Irrigation Department, Punjab.

(*Concluded from p.* 718)

38. VIEWS OF THE HON. MR. H. S. LAWRENCE.

The Hon. Mr. H. S. Lawrence, formerly Commissioner in Sind, and now Finance Member of the Bombay Government, wrote, with reference to the shortage of area cultivated in Sind in that year of drought and scanty river flow, 1918-19, as follows:—

"It is estimated that the summer harvest of food grains in Sind has decreased in area by 800,000 acres, or 33 %, and the outturn of the area cultivated has fallen short of the normal outturn by 400,000 tons of rice and millets ; and this winter harvest of wheat and pulses will fall short of a normal outturn by 100,000 tons ; i.e., a total reduction of food supplies of the Province from 1,100,000 tons to 600,000 tons. . . . . If the Barrage and the Main Canals dependent thereon had been constructed, the position would have been very different. These canals are estimated to supply water for an annual cultivation of 2,700,000 tons (of food and cotton). Of these 2,700,000 tons, 900,000 would be on lands at present wholly uncultivated, and on lands already cultivated 900,000 tons would be rendered secure and another 900,000 tons would be new cultivation.

"In a year of distress like the present, the outturn and value of these safeguarded crops would be £13,500,000. This year a liberal estimate would place the value of the crops at only £3,500,000. Thus the surplus value of the crops that would have resulted from the existence of the Barrage would be £10,000,000. The cost of the Barrage and Canals combined has been roughly estimated at this same figure of £10,000,000. Thus, the whole of the capital cost would have been saved to the country by the harvest of this single year."

This note of Mr. Lawrence's is impressive at first sight, but will not bear closer scrutiny. The value of the crops of Sind in the year 1918-19 was, not £3,500,000 only, but £5,600,000; and the cost of the Barrage and canals in practice would be nearer to £20,000,000 than to £10,000,000. The figures below are taken from the Administration Reports of the Province of Sind:—

TABLE IV.

Year.	Area Irrigated in Sind (acres).	Estimated Value of Crops Irrigated.	Value per Acre.
		Rs.	Rs.
1917-18	3,507,367	837,54,168	24
1918-19	2,630,776	846,47,368	32

The value of the crops raised during 1918-19 was actually greater than during the previous year. Mr. Lawrence would, no doubt, point to the fact that the area irrigated, and hence, presumably, the volume of agricultural produce, was 876,000 acres less in the year of drought, 1918-19, than in the year of abundant rainfall, 1917-18 ; and would argue that such a fluctuation of results could not occur on a well-regulated

perennial canal system. He is apparently unaware that the area irrigated by the perennial canals of the Punjab, taken in the aggregate, was one million acres less in the year 1918-19 than in the following year ; and that the area irrigated annually by these canals during the three years, 1917-18 to 1919-20, varied over a range of nearly 30 per cent.

39. Criticisms of the Estimates of the Sukkur Project (1920).

It is obviously impossible for me to discuss the whole project adequately within the limits of time and space which circumstances impose on me here. I will only briefly refer now to the salient features of the Project, leaving those who have time or inclination to consider the matter further to read my further discussions on the subject in Appendices which will be bound up with the printed report of the present discourse. The authors of the Project estimate that the same will be completed in the eleventh year after the commencement of construction, and that in the 21st year the area irrigated will amount to 3,741,000 acres ; and that 20 years later still, this area will have increased to 5,300,000 acres. In Appendices B, and E, I have discussed the matter, and arrived at the conclusion that the Project will not be completed till the 16th year, and that the area irrigated annually in the 26th year is not likely to exceed 3,700,000 acres; which will anyhow be the limit of area irrigated annually. The authors of the Project estimate that the cost thereof will be about 1,600 lakhs of rupees. The Government of India have found it advisable to increase that figure to 1,842 lakhs (£12,300,000). In Appendix C I have discussed the matter, and arrived at the conclusion that the cost will probably not be less than 2,534 lakhs (£17,000,000). Additional reasons for my estimate of cost will be found in Appendix D.

In Appendix F I have criticised the Project forecast of probable Gross Revenue, and have come to the conclusion that the proposed barrage will not improve the conditions of the existing rice irrigation of the Indus Valley; and that, therefore, although it may be permissible to charge the rice crop more for its irrigation than has been charged in the past, such enhancement of assessment should not be credited to the accounts of the Barrage Project *as, if fairly leviable, it will be leviable even if the Barrage be not built.*

The provision for working expenses in the Sukkur Project (1920) in the 26th year is Rs.50,28,000.

In Appendix G I calculate that this figure should be increased to Rs.83,20,000.

The authors of the Sukkur Project (1920), as revised by the addition of 255 lakhs of rupees to the cost thereof by the Government of India, reckon that the Project will yield financial returns as follows :—

Period after completion.	Percentage on capital.
10th year	— 5.57%
20th "	— 8.97%
30th "	—10.51%

Interest charges on borrowed capital being reckoned at 5 per cent.

My calculation, subjoined below, is that in the 10th year after completion (26th after commencement of construction) the nett revenue derived from the Project will be only 2.7 per cent. of the capital cost; and that it will be 68 lakhs of rupees (£450,000) annually less than the interest charges on borrowed capital (interest reckoned at 6½ per cent.).

40. Financial Forecast, Sukkur Barrage Project (1920) Reconsidered.

I have calculated that the area irrigated annually by this Project will not amount to more than 3,700,000 acres ultimately. The waterlogging of the soil will prevent any further increase of area, by rendering large tracts of the country independent of canal water for winter cultivation. I have calculated also that the capital cost of the Project is not likely to be less than 2,534 lakhs of rupees, or £17,000,000.

My forecast, therefore, works out as follows :—

Capital Cost	Rs.2534,00,000
Simple Interest at 6½% per annum	Rs. 164,70,000
Gross Revenue Receipts in the 26th year (10th year after completion) = 3,700,000 acres at Rs. 6 per acre ..	Rs.222,00,000
Working Expenses at Rs.200 per cusec of Canal Head Discharge	83,20,000
Total Nett Revenue ..	Rs.138,80,000

Deduct Nett Revenue earned by the existing canals ..	Rs. 42,00,000
Balance Nett Revenue due to Sukkur Barrage Project	Rs. 96,80,000

which is Rs.68,00,000 per annum less than the interest charges on the capital borrowed.

41. An Alternative to the Sukkur Project (1920).

The criticisms, here presented, of the Sukkur Barrage Project (1920) would not be complete if I did not indicate, in some manner, however sketchy, the outlines of an alternative to that Project.

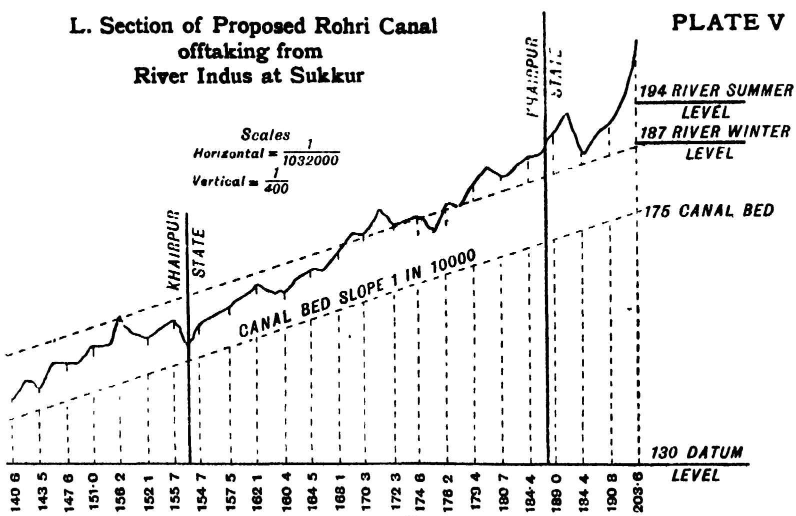
I would have no Barrage at all; since, in this particular case, a Barrage seems to be a needless and heavy item of expense. The Lower Swat River Canal, with Head at Abazai in the N.W. Frontier Province; the Upper Jehlum Canal, with Head at Mangla in the Punjab (or, rather, Kashmir); and the Trebeni Canal in Behar; are all examples of perennial canals which are fed from their parent rivers without the help of a barrage or weir across the latter; and the same arrangement is practicable, at Sukkur, on the Indus, in Sind.

Consider the case of the proposed Rohri Canal. The longitudinal section of the alignment of the first 80 miles, or so, of this Canal, is shown in Plate V. According to the Sukkur Project (1920), the gross area commanded by this canal would be 2,956,518 acres. Suppose we were to arrange to irrigate about 60 per cent. of this area annually; or, say, 1,800,000 acres; half in each season, viz., 900,000 acres in the summer, and the same in winter.

Allowing a cusec of full capacity for every 66 acres of summer irrigation, the discharge of the canal, at Head, would be 13,636 cusecs. The other features of design might be as follows:

Gradient $= \frac{1}{10{,}000}$; Kutter's N $= 0.025$;
Bed Width $=$ 400 feet; Water Depth $=$ 11 feet; Coefficient of Discharge $= 92.3$; Mean Velocity $= 2.99$ feet per second. Kennedy's Critical Velocity Ratio $= 0.77\ V_0$.

$$\text{Wood's Silt Index} = \frac{2.99}{0.37 \times 11} = \frac{2.99}{4.07} = 0.74.$$



The average water level of the Indus throughout the winter sowing season—October to December inclusive—is 187.5; and in the maturing season—January to March inclusive—it is 187.1.

At the site of the proposed Barrage, of the 1920 Project, the average water level is 186.8 in the sowing season, and 186.5 in the maturing season.

In this scheme (without Barrage) it will probably not matter much at which site the Rohri Canal off takes; but I will take the least favourable condition by assuming that it will be at the lower site, where a winter water level of 186.8 on the average, in the sowing season, may be expected.

Suppose we fix the full supply level of the canal at 186.0; so that its bed level, at

head, would be 175.0. We might give the Head Regulator a waterway 800 feet wide.. The discharge per foot run of cill would be $\frac{13635}{800}$ = 17 cusecs; and it would always be by "free" overfall over the top of movable gate-cills. The conditions of flow, in summer and winter respectively, would be as shown in Figs. (6) and (7) below:—

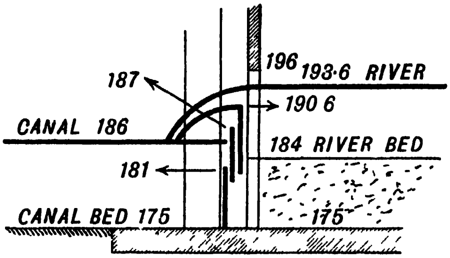


Fig. (6) Section through Canal Head on line of flow (Woods' Design)

The regulation of supply would be done by three tiers of gates in the summer, as shown in Fig. (6) above. The lowest gate would, in summer, always be resting on the floor of the Regulator; and the middle gate would also always be in the position shown, whenever the river water level is above 190.0. The top gate would pass down from above when required for use, and rise again from below, and the water would pass over its top by free overfall; and when the river is in high flood, above, say, 197.0, this gate could close the canal by abutting against a lintel at 196.0.

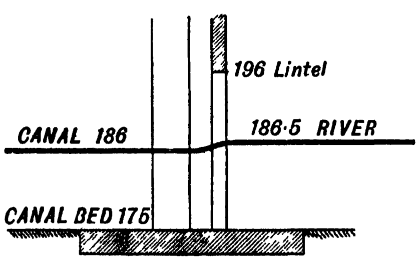


Fig. (7) Section through Canal-Head on line of flow (Woods' Design)

In the winter, all gates would be removed from the water, which would then flow into the canal, over the floor at 175.0, as shown in Fig. (7).

42. British Irrigation Enterprise.

The vast and lucrative irrigation works which exist in most Provinces of India—the Periyar Dam and the Anicuts of Madras, the notable Reservoir Dams of the Deccan and Gujarat, the Ganges Canal, the perennial canal systems of the Punjab, and the Inundation Canals of Sind—are monuments to the patient and intelligent labours of the British bureaucracy in India. Now that that bureaucracy is giving place to the new democracy, it would be satisfactory if these monuments of British enterprise could be handed over to the Indian public, as they are, with hardly a single failure amongst them. Before the Sukkur Barrage Project (1920) is put in hand, therefore, the Government of India would do well to subject it to closer scrutiny, than has hitherto been applied to it, with regard to:—

(*a*) Risk of waterlogging of the soil.

(*b*) Risk of silt-trouble in the canals.

(*c*) Risk of shoaling of the river, and possible avulsion thereof, as a consequence of obstruction to its flow by the Barrage.

(*d*) Risk of financial failure, resulting from under-estimation of cost of the Project; and over-estimation of its revenue receipts.

APPENDIX A.

The Area Regarded as Culturable in the Project.

The Project under consideration, which I may call briefly the "Sukkur Project, 1920," provides for the construction of a Barrage, or bridge fitted with sluice gates, across the River Indus, about three miles downstream of the rocky gorge at Sukkur; and for the construction of five canals, viz., three on the right bank, and two on the left bank, to take up and extend the irrigation of all the existing "inundation" canals that off take from the river, from just above the Sukkur (or Bhukkur) gorge, and the town of Hyderabad; a distance of 240 miles. The area commanded by direct gravitation flow from these canals will amount to about 7,500,000 acres; and the authors of the Project claim that 87 per cent. of this area, or, say, 6,500,000 acres, consist of good soil that is not only available for irrigation—not being taken up for other purposes, such as roads, canals, habitations, etc.—but is also culturable *Prima facie* this claim seems to err on the side of optimism. In the tracts irrigated by the Punjab Inundation Canals, which are of alluvial formation, similar to that of Sind, the culturable area amounts to only 82 per cent. of the gross area (4,700,000 acres).

In the irrigated tracts of Madras, which are mostly of deltaic formation, out of a gross area of 7,100,000 acres, only about 70 per cent. (4,960,000 acres) is culturable and available for irrigation. It seems unlikely, therefore, that more than 80 per cent. of the gross area

comprised in the Sukkur Project can be reckoned upon safely as culturable and available for irrigation.

In the year 1910, in connexion with a previous project for the irrigation of Sind, a soil survey of the tract to be irrigated by the proposed Rohri Canal on the left bank of the Indus, was prepared by Mr. Lucas, I.C.S., a competent Revenue Officer, who estimated the culturable area there to be 2,120,000 acres. For the purpose of the 1920 Project, a fresh soil survey was ordered by the Government of Bombay in the year 1915; and Messrs. Baker and Lane were placed in charge of it. They increased Mr. Lucas' figure of culturable area by 380,000 acres: and it can reasonably be inferred that this difference of estimation by two sets of equally expert observers may have been due to the one estimate having been prepared in a spirit of caution and the other in a spirit of optimism. Similarly, in the case of the East Nara tract, Messrs. Baker and Lane, without having seen the tract, increased Mr. Lucas' estimate of its culturable area very considerably. Now, nothing is easier than for two or more individuals, or parties, to differ materially from each other in estimates of this nature; but the financial forecasts of a vast irrigation project ought not to be based on optimistic estimates. In a Report by Lieut. Fife, R.E., dated September, 1852, I find the East Nara tract described as follows:—

> "The country, which is denominated the *Thurr*, is covered with enormous sandhills, extending on every side as far as the eye can reach, and presenting a singular but very desolate appearance."

The name *Thurr* (Thar), is the same as the name Thull (Thal), which is applied to the country between the Indus and Chenab Rivers further upstream, and implies bottom-land, interspersed with sandhills. In the Thal Canal Project of the Punjab the Chief Engineer, Punjab, reckoned for purpose of Project forecast, that only 50 per cent. of the gross area of the Thal is culturable. In the year 1910, Sir J. Benton, Inspector General of Irrigation, wrote of the East Nara tract as follows:—

> "It has a high spring level, a sparse population; is unhealthy, and in many parts does not admit of intense irrigation."

On the whole, it cannot be regarded as prudent to reckon the culturable area of the Sukkur Project (1920) to be more than 80 per cent. of the gross area; or, say, 6,000,000 acres

APPENDIX B.

The Annually Irrigable Area of the Project.

Intensity of Irrigation.

In the Punjab and in the United Provinces, the areas irrigated annually by the perennial canals bear the following percentage ratios to the gross area commanded by each canal:—

Canal.	Per cent.	Canal.	Per cent.
West Jumna ...	28	Sirhind ...	28
Upper Bari Doab	65	Lower Chenab	70
Lower Jhelum ...	58	Upper Ganges	24
Lower Ganges ...	15	East Jumna ...	29

In the Sukkur Project (1920) it is proposed to irrigate annually 71 per cent. of the gross area; an intensitv of operation which has been approached only in the case of the Lower Chenab Canal. But the conditions of the Lower Chenab Canal are very different from those of the Sukkur Project. In the greater part of the tract irrigated by the Lower Chenab Canal, the subsoil water table was, before the opening of the canal, more than 100 feet deep below ground surface. It has risen 40 feet in 20 years, and is still a long way below surface; but the day will surely come, even though it be another 20 years distant, when the subsoil water will be so close to the ground surface in most places, as automatically to reduce the total area irrigated annually. Already in the upper reaches of the canal, where the spring level was, 20 years ago, about 40 feet deep below ground surface, it has risen so close to the surface that the cultivators have ceased to take canal water in the winter season The same result is likely to follow closely on the heels of the Sukkur Project (1920), which proposes to irrigate tracts whose subsoil water level is generally less than 40 feet below ground surface, and in many places even 20 feet, or less. In the case of the Triple Canal Project of the Punjab, it was proposed to irrigate perennially from the Upper Chenab Canal all commanded areas whose spring level was deeper than 25 feet below ground surface. The spring level in these areas was usually more than 35 feet deep; but although the canal has been only a few years in operation, the spring level has risen so rapidly that everywhere it is now less than 25 feet below surface, and it has been found necessary to discontinue irrigation, during the winter, over a considerable proportion of its commanded area. So far as I can see, there is nothing to prevent a similar result in the case of the Sukkur Project (1920). If that occurs, it will be fatal to the Project, which depends mainly, for its financial success, on an area of winter irrigation double that which is designed to be irrigated by it in the summer.

In the case of the Upper Bari Doab Canal, in the Punjab, it has been found necessary to discontinue winter irrigation from the upper reaches of the canal (100 miles or so), with the result that the area irrigated by this canal, as a whole, is less in the winter than in the summer. In the tracts irrigated by the Lower Jhelum Canal, the rise of spring level since the opening of the Canal has been remarkably rapid; and, in fact, experience of perennial irrigation in the Punjab has been generally that the spring level is liable to be raised, by percolation

from perennial canal systems, at the rate of about two feet vertically per annum.

That experience indicates that it is inadvisable to allow winter irrigation to tracts in which the spring level is less than 25 feet below ground surface, and such irrigation is officially prohibited. The Sukkur Project (1920) ignores all this; doubtless in consequence of the Bombay engineers lacking experience of perennial canal irrigation.

In the case of the Triple Canal Project, which is the latest illustration of Punjab irrigation practice, the designs allowed for the irrigation annually, wherever spring level was deeper than 25 feet below ground surface, of 75 per cent. of the culturable area, or 63 per cent. of the gross area, after deducting from these areas the areas hitherto irrigated from wells. The Government of India should not allow the financial forecasts of the Sukkur Project (1920) to rest on a reckoning of an annually irrigated area greater than 60 per cent of the total culturable area, or 50 per cent. of the gross area

This will mean restricting forecasts to a reckoning of an irrigation of 3,700,000 acres annually, instead of the Project figure of 5,300,000. Even this figure is not likely to be worked to unless the area of winter irrigation is reduced to something equal to, or less than, the area of summer irrigation. For it is the winter irrigation mainly that waterlogs and impoverishes the soil, and throws it out of cultivation in consequence

2. WATERLOGGING.

The evil of waterlogging, as a result of irrigation, is one which is seriously felt chiefly in tracts which are irrigated perennially, i e, in the winter as well as in the summer. In tracts in which summer irrigation only is practised, the evil is not much in evidence, because summer irrigation is rarely practised for more than 4 or 5 months in the year; so that any soil which may become flooded or saturated during that period has an interval of 7 or 8 months during which the surface or subsoil water is able to drain off; and permanent stagnation of the subsoil water does not occur.

In the Punjab, the problem of prevention of waterlogging is always in the forefront of the minds of irrigation engineers, or other officials who may have to deal with irrigation; and it is with them a well-established principle that perennial canal irrigation shall not be introduced into a tract in which the spring level is less than 25 feet below ground surface. The importance attached by the Punjab Government to the subject is sufficiently indicated by its appointment, within recent years, of a Drainage Board, amply provided with funds, to formulate schemes for the prevention of waterlogging.

3. THE PRESERVATION OF WELL IRRIGATION.

In the Punjab it is also a well-established principle that perennial canal irrigation shall not be introduced into a tract which is already irrigated to a great extent by wells: the idea being that well-irrigation tends to keep down the subsoil-water level at a safe depth; besides helping to maintain a good supply of draught-cattle.

The Bombay-Sind officials, however, propose to introduce perennial canal irrigation into tracts with spring level less than 25 feet below ground surface; and to throw the irrigating wells out of action; with the object apparently of showing, on paper, financial profits that in my opinion are not at all likely to materialise. In the Report of the Sukkur Project (1920) we find it stated, as regards the tracts on the right bank of the Indus:—

> "DEPTH OF SUBSOIL WATER. This varies considerably in different parts of the tract. In Talukas, Kakkar, Dadu, Johi, and Sehwan, it varies from 20 to 25 feet or more. At present there is a fair amount of well cultivation in the *rabi* season.
>
> In the Central Rice tract the subsoil water level is high, and wells are used for raising rice seedlings.
>
> In the Northern *talukas* of the North West perennial area, the water level is much deeper, as much as 40 feet, and but little well irrigation is practised.
>
> The wells will be useful for domestic supplies in future, but will hardly be needed for irrigation."

4. LEVEL OF SUBSOIL WATER TABLE.

The soil of Upper Sind, as we have noted above, has been formed alluvially by deposit from the river's floods. That indicates that the ground surface is everywhere below High Flood Level. And as the subsoil water table is fed by percolation from the river, it follows that it cannot be far below ground surface. At present the subsoil water table slopes away on both sides from the river's edge (see Plate II, Fig. (a)); but when canals are in flow perennially, at distances of 10, 20, or 60 miles, from the river, and roughly parallel to its course, each of these canals will become a separate source of percolation flow to the subsoil water table, which will rise everywhere to within less than 10 feet below ground surface.

Plate III, Fig. (c) shows the subsoil water conditions in Middle Egypt; but the conditions in Sind will be much worse, because Egypt has safeguards which will not exist in Sind, viz:—

(*a*) The area irrigated in Middle Egypt in the winter is much less than it is in the summer; whereas in Sind, according to the Sukkur Project, it will be twice as great.

(*b*) The Bahr Yusuf is at a relatively low level, and acts as a drain to the subsoil water, but there is no corresponding provision in the Sukkur Project (1920).

(c) Much of the irrigation practised in Egypt, even from the perennial canals, is by "lift"; whereas the irrigation of the Sukkur Project (1920) is to be entirely by "flow," from elevated water channels.

5. PROPORTIONATE AREAS OF SUMMER AND WINTER IRRIGATION.

I have drawn attention to the similarity of physical conditions, as to soil and hydraulics, that exist between Sind and Egypt. The Sukkur Project (1920), however, draws no useful lessons from irrigation experience in Egypt. In Upper Egypt only 43 per cent. of the culturable area is allotted to perennial irrigation, and less than 20 per cent. of the culturable area is irrigated in the winter, or low-water season. In Lower Egypt about 27 per cent. of the culturable area is irrigated in the winter.

In Madras the area irrigated in the winter is insignificant; except in the Godavari delta; where, however, the winter-irrigated area is yet less than the summer-irrigated area.

There is, in fact, no justification in past irrigation experience, either in or out of India, for the supposition on which the Sukkur Project (1920) is based, that the winter-irrigated area, under this Project, will in practice be double the summer-irrigated area, in the ratio of $\frac{\text{winter}}{\text{summer}}$ irrigation $= \frac{54}{27}$ per cent. of the culturable area.

Even the Bombay Government seems to have been conscious of this, for in a letter dated 30th August, 1918, whilst approving of the intensities :—

Kharif ... 27 per cent. of culturable area.
Rabi ... 54 " " "

it remarked that :—

"It was not expected that this area would be reached at any early date, but provision was to be made for it. *In the final estimates only 27 per cent. of the culturable area would probably be estimated as rabi area.*"

The forecast of winter-irrigation from perennial canals, as set forth in the Project Report, must be reduced from 5,308,000 acres to 3,700,000 acres; by cutting out the 1,600,000 acres of winter-irrigation that will never materialise; or that, at any rate, will not do so within 10 years of the date of completion of construction. The perennial canals should, in fact, be designed to irrigate equal areas in the summer and winter seasons, and the financial forecasts should take into reckoning a winter-irrigation equal to about 27 (not 54) per cent. of the total culturable area, as was considered prudent by the Bombay Government even so lately as in August, 1918.

6. FORECAST OF AREA TO BE IRRIGATED EACH SEASON, ANNUALLY.

The authors of the Sukkur Project (1920) reckon that their Project will begin irrigation in the seventh year after commencement of construction; that construction will be completed in the eleventh year; and that in the 21st year, 10 years after completion, the area irrigated will be 3,741,000 acres.

The existing canals on the right bank already irrigate 894,000 acres annually, out of which 575,000 acres are under rice, and will not be fit hereafter for anything but summer irrigation. Deducting these 575,000 acres from 3,741,000, we have left 3,166,000 acres, which, under the Project design are to be irrigated, 1,055,000 acres in the summer and 2,110,000 in the winter.

Thus the total summer irrigation will be, according to the Project, $575{,}000 + 1{,}055{,}000 = 1{,}630{,}000$ acres; as compared with 2,110,000 acres in the winter.

My opinion is that this forecast of 2,110,000 acres of winter-irrigation will probably not materialise; and that the winter area, will not be greater than the summer area (compare the West Jumna and Upper Bari Doab Canals); and that, therefore, the area annually irrigated, in the 10th year after completion, may not exceed $1{,}630{,}000 \times 2 = 3{,}260{,}000$ acres.

We may look at it another way. The Project forecasts an ultimate irrigation annually, in the 41st year, of 5,300 000 acres. Deducting 575,000 acres of rice from this, leaves us 4,730,000 acres, of which the forecast is $\frac{1}{3}$ summer, $\frac{2}{3}$ winter irrigation. Thus we arrive at :—

$575{,}000 + \frac{4{,}730{,}000}{3} = 2{,}152{,}000$ acres summer-irrigation, and $\frac{4{,}730{,}000 \times 2}{3} = 3{,}154{,}000$ acres winter-irrigation. My view is that the winter irrigation will not exceed $\frac{4{,}730{,}000}{3} = 1{,}577{,}000$ acres; and that the area irrigated annually will not exceed $2{,}152{,}000 + 1{,}577{,}000 = 3{,}729{,}000$ acres—which is practically the same figure as stated in the Project for the 10th year after completion.

The letter, dated 30th August, 1918, quoted above, shows that the Bombay Government itself did not expect the area of winter irrigation to exceed that of the summer irrigation by the 10th year after completion; and my opinion is that no greater area of irrigation than 3,700,000 acres per annum can ever be expected from this Project.

I reckon that the Project will not commence irrigation till the 11th year; that it will not be completed till the 16th; and that the irrigation of 3,700,000 acres cannot be expected before the 26th. Beyond the 26th year no increase of irrigation can be expected, because the rise of spring level will render large acres independent of canal water for *winter irrigation*, even if it does not throw the land out of cultivation through *waterlogging*.

APPENDIX C.

The Project Estimates of Cost.

A simple check on the sufficiency of the estimates of cost of the Sukkur Project (1920) may be found in a comparison with the figures of the Triple Canal Project, the latest irrigation work in the Punjab, completed in 1912-1915.

The Upper Chenab Canal and Lower Bari Doab Canal of that system from one combined canal, have a capacity at head of 11,700 cusecs. The revised estimate of its cost, direct and indirect, amounted to Rs. 596,85,426; or, say, *exclusive of cost of river works*, Rs. 500,00,000. This, *exclusive of river works*, is equivalent to a cost of $\frac{500,00,000}{11,700}$ = Rs. 4,274 per cusec of full capacity at head. The authors of the Sukkur Project profess to have allowed in their Project for a rise in cost of labour and materials of 30 per cent. over pre-war rates. An increase of 30 per cent. on the cusec-rate of cost of the Upper Chenab Canal would raise it from 4,274 to 5,556 per cusec of capacity at head.

Let us compare this with the figures of the Sukkur Project

The figures of the proposed Rohri Canal of the 1920 Project are:—

Capital cost of Canal exclusive of barrage, direct and indirect Rs. 408,00,000

The head capacity of this canal is to be about 11,000 cusecs, so that its estimate of cost works out to Rs 3,700 only per cusec of head capacity, instead of 5,556, as it ought to work out to.

These figures suggest that the estimate of cost of the Rohri Canal should be increased by 50 per cent., to make it a safe estimate.

Similarly, the estimate of cost of the Right Bank Canals of the Sukkur Project is as follows:

Capital Cost of Canal, direct and indirect ... ... Rs. 618,18,000
Head capacity = 19,433 cusecs
Rate of cost per cusec = Rs. 3,181 only.

And in the case of the Nara Canal system:

Capital cost of canal, direct and indirect ... ... Rs. 239.92,000
Head capacity = 12,200 cusecs.
Rate of cost per cusec = Rs. 1,967 only.

The authors of the Project claim that the rates of cost allowed in the estimates of the Right Bank Canals and the East Nara Canals, are 30 per cent. in excess of the rates allowed in the 1910 Project; but that, owing to economies of design, the excess has been reduced to 6 per cent. They have also gone on the assumption that the cost of remodelling an existing canal is only about one-fifth the cost of making a totally new canal of similar dimensions. These contentions cannot be admitted. My experience of remodelling existing canals has been, generally, that the remodelling may cost 60 per cent. of the cost of new construction, even in cases where the alignment is not altered.

If, however, we add only 50 per cent. to the cost of these estimates, as arrived at by comparison of the Rohri Canal estimates with those of the Triple Canal Project, *plus* 30 per cent., we arrive at the following result:—

	Rs.
Capital Cost, Direct and Indirect, exclusive of Barrage, Sukkur Project (1920)	1382,00,000
Add 50 per cent.	691,00,000
Total	2473,00,000
Add cost of Barrage (nett) ...	461,00,000
Grand Total	2534,00,000

2. Estimate Rates.

The Government of India, before passing on the Project to the Secretary of State for India for sanction, increased the estimate of cost of ironwork of the Barrage, generally, from Rs.75,00,000 to Rs 200,00,000; and that for Plant from Rs.130,00,000 to Rs. 260,00,000; a total increase of 255 lakhs of rupees.

They overlooked the necessity of revising the rates for other classes of work; which can be seen, from the comparison, below, of the Project rates for the Barrage (1919), and Canals (1920), with the rates current in the Punjab in 1920:—

Class of Work.	Rates of Cost (Rupees). Sukkur Barrage Estimate, 1919.	Sukkur Canals Project, 1920.	Punjab Rates, 1920
Concrete of Brick Ballast and Kankar Lime	—	32	35
Concrete of Brick Ballast and White Lime	17/8/-	26	35
Concrete Stone Ballast and Kankar Lime	—	25	35
Concrete in Cement Mortar	45	80	70 to 80
Random Rubble Masonry	27	30	45
Coursed Rubble Masonry	40	—	50

This statement shows that the current market rates in the Punjab in 1920 for these classes of work, were from 18 to 44 per cent. higher than the rates that have been allowed in the Sukkur Project estimates.

It is difficult to say what total difference in cost it would make to level up the Project rates to the Punjab standard; but the figures stated tend to shake confidence in the sufficiency of the Sukkur Project estimates.

3. Hill Torrent Works, N.W. Canal.

No provision has been made in the estimates of the Sukkur Project (1920) for the cost of works designed to pass the floods of the hill-torrents of the Baluchistan border across the North-West Canal. The proposal is to debit the cost of such works to a separate Provincial Fund, instead of to the Project estimate. This makes the Project appear (on paper) cheaper than it really is. It has been the established practice of the past, as, for instance, in the Ganges, Sirhind, Upper Jhelum, and other Canal Projects, to debit to the Project estimates the cost of all such Cross-Drainage Works; which has often been a very serious feature of expense. In the case of the Upper Jhelum Canal, the cost of the Cross-Drainage Works amounted to about 150 lakhs of rupees (£1,000,000), or rather more than one-third of the entire cost of the Canal system.

The Paharpur Canal, a canal somewhat similar to the North-West Canal of the Sukkur Project, but offtaking from the Indus some hundreds of miles further upstream, has proved a financial failure, by reason of the unforeseen magnitude of cost of its Cross-Drainage Works. In the case of the N W. Canal, the authors of the Sukkur Project (1920) take credit for the revenue accruing from the extension of the Canal to command an area of 400,000 acres of new land along the Baluch border, but they shirk debiting the full cost of that extension to their Project. This is not right. The cost, which may, perhaps, amount to half a crore of rupees (say, £300,000), should be added to the Project estimates.

4. Provision for Maintenance Before Completion.

It has been the established practice, in the past, to provide, in canal irrigation projects, for the cost of maintenance of canal works between the date of their completion and the date of commencement of irrigation and earning of revenue. No such provision has been made in the Sukkur Project (1920). That it ought to be made is obvious. In the case of the Triple Canal Project, the actual cost of this maintenance was, under pre-war conditions, 20 lakhs of rupees; equivalent, under post-war conditions, to 26 lakhs. This suggests that the corresponding provision in the Sukkur Project (1920) should have been about 50 lakhs of rupees, or, say, £300,000.

5. Probable Total Cost.

There are other numerous instances of omission, or of under-estimation, in the estimates of the Sukkur Project (1920), which need not be described in detail, but which all support the general conclusion that the total cost of the Project, instead of being put at 1,600 lakhs of rupees, as stated by the Government of Bombay, or at nearly 1,842 lakhs (£12,300,000) as revised by the Government of India, ought really be increased to at least 2,534 lakhs, or, say, £17,000,000; reckoned at the exchange rate of sixteen pence per rupee.

APPENDIX D.

1. Canal Designs—Kutter's Coefficient.

The canals of the Sukkur Project (1920) have been designed on a uniform system. We may examine the design of the proposed Rohri Canal in its head reach, as typical of all.

Rohri Canal.

Discharge = 10,992 cusecs. Gradient 1 in 15,600. Bed-width, 253 feet. Full water depth, 13 feet. Kutter's N. = 0.020. Mean velocity, 3.26ft. per second. Kennedy's critical velocity ratio, 1.002.

The value of Kutter's co-efficient is not likely, in practice, to be so low as 0.020. In the Punjab, the practice has been, for 20 or 30 years past, to design main canals on the assumption that N = 0.0225.

In the Triple Canal Project the value of N was at first put inadvertently at 0.020, but the error was rectified before the canals were completed.

In practice, the main perennial canals of the Punjab exhibit in their head reaches even greater rugosity than is implied by N = 0.025. Careful hydraulic surveys have established the average value of N in the following canals, thus:—

West Jumna Canal—Dadupur to Indri	N = 0.031
Upper Bari Doab Canal—Tibri to Aliwal	N = 0.027
Lower Chenab Canal—First 16 miles	N = 0.027

The soil of Sind is said to be lighter and more friable than that of the Punjab, but even if it be not, it is quite on the cards that the canals of the Sukkur Project may exhibit a rugosity implying that N = 0.027. The relative narrowness and great depth of the Rohri Canal (as per Project, 1920) will aggravate the tendency of the sides of the canal to cave in by erosion, thereby increasing its rugosity. Even if we credit it with a rugosity no worse than N = 0.025 the design will be affected as follows:—

Bed width=253. Water depth=14.3. S=.000064. Kutter's N=.025. Mean velocity=2.86. Discharge=10,931. Kennedy's critical

$$\text{Velocity ratio} = \frac{2.86}{4.6} = 0.62 \text{ Vo.}$$

2. SILTING OF CANALS PROBABLE.

This means that the mean velocity of the current, instead of being equal to Kennedy's Critical Velocity, would be only 62 per cent. of that velocity; and the chances of the canal suffering from silt deposits would be far greater than supposed by its designer.

Again, the water depth required for a discharge of 10,992 cusecs would be rather more than 14.3 feet; so that, with bed level at 180 feet above mean sea-level, the full supply level of the canal would be at 194.3, instead of at 193.0 as designed. And this would require a water level of about 195.0 in the river; whereas the top of the barrage gates will be at R.L. 194.5 only.

If the canal suffers from silt deposits, as it probably would, with mean velocity=0.62 Vo only, even higher water levels will be required in canal and in river, in order to force 10,992 cusecs over the shoal, or silt-deposit, in the canal.

These remarks suffice to show the defective nature of the designs of the Sukkur Project (1920) Canals.

In order to obviate the inconvenience of heading up the river water surface above 194.5, so as adequately to feed the canals, it will be necessary to make the Rohri Canal wider than it has been designed in the 1920 Project, and at a lower level. And this will mean additional expense, which must be added to the provision in the estimates.

The other designs are open to the same objections, except that the cases of the Central Canal on the right bank, and also of the East Nara Canal, will be worse, since they are designed with full supply level at 194.0, and might need a water level of 196.0, or higher, in the river, in order to feed them adequately.

In assuming that Kutter's N for their canals will be so low as 0.020, the authors of the Project have been guided probably mainly by an impulse to keep down the cost of the canals *on paper*. They rest this figure on an Inspector-General's order dated January, 1907; which, however, was superseded by a subsequent order issued in the Punjab, by the same authority. In any case it is impossible for any expert to deny that the Sukkur Canals may have a coefficient of rugosity as high as 0.025, or even 0.027, in their head reaches; and no design should be passed which does not allow a sufficient margin of command, between river water level and canal water level to ensure complete supply to the canals at all times and under any probable adverse conditions.

In the 1920 Project the new Nara Canal has been designed with bed width 350 feet and water depth 11.5 feet; and it is not apparent why the Rohri Canal has been designed so much narrower and deeper.

In my opinion a bed width of about 400 feet and water depth of about 10 feet would be more suitable in either case.

3. LOSS OF "HEAD" IN ENTRY.

The 1920 Project assumes that the loss of head of water between river and canal will be only 0.3 foot; but this is only another instance of undue optimism. In the summer the river will be flowing past the canal head, at right angles to the direction of the canal, with a mean velocity of six or seven feet per second. In order to enter the canal the current will have to swing round through a quadrant; it will strike the piers of the canal head obliquely, and the disturbance set up will be such that the loss of head in entry cannot safely be put at less than, say, 0.7 foot.

APPENDIX E

DURATION OF EXECUTION OF THE PROJECT.

The authors of the Sukkur Project (1920) forecast that its construction will be completed within 12 years. This is too optimistic.

The Lower Chenab Canal, in the Punjab, has a head discharge of about 10,700 cusecs, and it took about 12 years, reckoning from commencement of the head works, to complete that system. Similarly, it took 12 years to complete the combined Upper Chenab and Lower Bari Doab Canal, which has a head discharge of 11,000 cusecs.

The Sukkur Project comprises five separate canals, with discharges as follows:—

Rohri=10,992 cusecs; East Nara=12,200; Right Bank (Central)=12,350; North West=4,300; South East (right bank)=2,800 cusecs.

It seems clear that it will take much longer than 12 years to complete all these canals, whose aggregate head discharges amount to 42,600 cusecs.

There are several reasons which militate against the likelihood of rapid progress of construction on the Sukkur Project. At the time the Lower Chenab Canal was under construction there was no other irrigation work of great magnitude under construction in Northern India; and so that canal had command of the entire labour market of Northern India and Afghanistan and Baluchistan.

The same was the case with the Triple Canal Project, when it was put in hand later on. But the Sukkur Project will have many rival schemes of construction competing with it in the market for labour and materials. Amongst these may be mentioned the Sutlej Valley Canals Project in the Punjab, estimated to cost 1,400 lakhs; and another Project of similar magnitude in the United Provinces.

The labour market has, moreover, been depleted, since the construction of the Triple Canal Project, by the severe malaria epidemic of the year 1917, the calamitous influenza epidemic of 1918, and the Great War of 1914-18. Taking all this into account, it seems likely that it may take 20 years to complete the Sukkur Project (1920); and, at any rate, the period cannot reasonably be put at anything less than 16 years.

APPENDIX F.

GROSS REVENUE RECEIPTS.

I have calculated, elsewhere, that the annually irrigated area, which has been estimated in the Sukkur Project to amount to 5,300,000 acres in the 40th year after commencement of construction, is never really likely to exceed 3,700,000 acres. And if we allow that it is possible to complete the Project within 16 years, we may infer, from experience in the Punjab, that the irrigated area in the 26th year (10 years after completion), may amount to 3,700 000 acres; though it is not likely to be fully developed by that time. Moreover, the revenue calculations should show a deduction for *Kharaba* remissions, and remissions under Tenancy Rules.

It is stated, in the Sukkur Project Report, that the area at present irrigated in the tracts comprised in the Project is 2,035,636 acres; and the revenue assessed on that area amounts to Rs. 61,51,691; or to about Rs. 3/- per acre. It is estimated that the canals of the Project will begin to irrigate in the 7th year from commencement of work, and that in that year the area irrigated will increase to 2,240,142 acres, whilst the revenue will jump up to Rs. 99,67,631, implying an average rate of 4/8/- per acre. The increase of area of new land irrigated will be only about 204,000 acres, whilst the increase of revenue is put at Rs. 38,00,000. This is not a reasonable forecast. It will not be practicable to increase the assessment, on the existing irrigation of two million acres, so suddenly as that. The increase will have to be far more gradual. This applies to irrigation other than that of rice. In the case of rice-irrigation, it is difficult to *credit the Barrage Project accounts* with any increase of assessment. Consider the case of the Right Bank Canals, which at present irrigate about 900,000 acres annually, mostly rice. The Barrage will not in any way improve the water supply for rice-irrigation, but, on the contrary, it will reduce the abundance thereof.

The average water surface levels of the Indus during the monsoon months, at the Bhakkur gorge are:—June, 194.5; July, 196.0; August, 197.5; September, 194.4.

The Barrage, three miles further down the river, will give the Canals water levels ranging from 193 to 194 only. This is no improvement on the conditions of the existing canals, which offtake at Bhakkur, but a change for the worse

It is true that the Barrage will give higher water levels in April, May and October than the existing levels, which range from 188.5 to 191.5; *but this will not help the rice crop, which does not need irrigation before June nor after September.*

How, then, can the Barrage be fairly credited with the proceeds of an increased assessment of revenue on rice irrigation? If it be fair to increase that assessment, and if the rice crop can afford to pay that increased rate, the increase can be imposed *now, whether the Barrage be built or not.* The amount of the increased assessment cannot fairly be credited to the Barrage Project *as an asset that can be created only by means of the Barrage.*

We may concede that it will be permissible to levy the enhanced assessment of Rs. 6/- per acre on all existing irrigation with effect from the 26th year after commencement of construction; but the enhanced assessments on rice, at least, and on all June-September crops, should be treated as existing revenue, and not treated as an asset of the Barrage Project Accounts.

APPENDIX G.

WORKING EXPENSES.

The Sukkur Project (1920) aims at constructing canals modelled on the Punjab perennial canal pattern; but it reckons Working Expenses to amount to only Rs. 1.25, or slightly less, per acre irrigated annually. This calculation is not justified by Punjab experience, the cost of working the Punjab canals being as follows:—

TABLE V.

Canal.	Area Assessed (Acres).	Working Expenses (Rs.)	Cost per Acre Assessed (Rs.)	Canal Head Discharge. (Cusecs.)	Cost per Cusec of Discharge. (Rs.)
West Jumna	746,000	15,36,000	2.06	6,400	240
Sirhind	1,293,000	20,50,000	1.59	8,500	241
Upper Bari	1,123,000	13,94,000	1.24	6,700	208
Lower Chenab	2,347,000	23,54,000	1.00	10,700	220
Lower Jhelum	778,000	9,29,000	1.20	4,000	232
Upper Chenab / Lower Bari }	1,071,000	24,05,000	2.24	11,700	206
Lower Bari	634,000	11,23,000	1.77	6,750	166
Averages			1.59	7,820	216

The average cost per acre assessed annually, for all these canals, works out to Rs. 1.6 per acre; but the authors of the Sukkur Project (1920) provide for working expenses at the rate of Rs. 1.25 per acre only. They forecast that the area irrigated in the 26th year will be 4,060,000 acres, and the Working Expenses Rs. 50,28,000. If they had calculated the latter at the 1.6 rate their estimate of expenses would have amounted to 65 lakhs of rupees per annum, instead of 50 lakhs only. Whilst, if they had taken their rate of cost at Rs. 2/- per acre (as obtained on our latest Punjab Canals, the combined Upper Chenab and Lower Bari) their Working Expenses would figure out to Rs. 81,20,000 in the 26th year.

On the whole, it seems soundest to estimate the Working Expenses thus:—

TABLE VI.

Canal.	Canal Head Discharge (cusecs).	Rate per Cusec. (Rs.)	Working Expenses in 26th year. (Rs.)	Area Irrigated (Acres).	Cost per Acre (Rs)
Rohri	11,000	225	24,75,000	14,00,000	1.77
East Nara	12,200	200	24,40,000	10,00,000	2 44
Right Central	12,350	154	19,00,000	4,70,000	4. 0
Right N.W.	4,300	220	9,45,000	5,40,000	1.75
Right S.E.	2,800	200	5,60,000	2,90,000	1. 9
	42,650	200	83,20,000	37,00,000	2 24

which amounts to 33 lakhs of rupees per annum in excess of the provision in the estimates of the Sukkur Project (1920.)

Looking at the matter in a broad common-sense way, we see from Table V. above, that the Lower Chenab Canal, with a Head Discharge of 10,700 cusecs, costs Rs. 23,54,000 annually to maintain; and there is no very apparent reason why the proposed Rohri Canal, with a Head Discharge of 11,000 cusecs, should cost only Rs. 17,59,000 annually to maintain, as is calculated in the Sukkur Project (1920).

Similarly, the East Nara Canal, with 135 miles length of Supply Channel in the conditions of a natural river, will require enormous expenditure on maintenance and improvements, as part of a perennial canal system. Its conditions will be somewhat like those of the West Jumna Canal, only worse.

DISCUSSION.

THE CHAIRMAN (Lord Lamington), in opening the discussion, said it might appear to be exceedingly easy to irrigate land by means of water from a canal, but many people did not take cognisance of the difficulties connected with the water-logging of the land and the silting up of the canals. The outstanding interest of the paper was the author's views on the proposed Sukkur Barrage. That project was mooted during the time he (the Chairman) was Governor of Bombay, between 1903 and 1907, and he was optimistic enough to think that a start might be made on the work before his term of office expired, but up to the present nothing had been done. A year ago he had the honour of presiding at a lecture, delivered by Dr. Summers before the East India Association, which was confined entirely to the Sukkur Barrage, and all who took part in the subsequent discussion agreed with the views of the lecturer. Dr. Summers's conclusions seemed to be so reasonable that he felt there must be some extraordinary error of judgment on the part of those at the present time who were responsible for suggesting that the Sukkur Dam should be built before trying the far simpler project of cutting the canal as described by Mr Woods. To the best of his knowledge, the Secretary of State had never advanced a single argument on any occasion in favour of commencing the building of the Sukkur Barrage, before trying the far simpler, cheaper and almost immediately remunerative work of cutting the canal. Of course it was impossible to say what a river would do once its water supply was tampered with, and it might be necessary subsequently to build a barrage, but why one of the biggest engineering projects ever placed before the world should be begun before the far less costly project referred to was impossible for him to understand.

THE SECRETARY of the Section read the following message from Lord Sydenham:—

"I deeply regret that pressure of work prevents my being present. I have stated my views of the 1920 Project plainly in the House of Lords. This Project is one which I, as Governor of Bombay, would never have approved. I think that Dr. Summers has conclusively shown that it is radically unsound financially, and that if carried out the effects will be disastrous."

SIR LIONEL M. JACOB, K.C.S.I., late Secretary to the Government of India, in the Public Works Department, said that he was quite sure that all engineers interested in irrigation, and all those interested in the welfare of India, particularly of Sind, would welcome the paper by Mr. Woods, a scientific engineer of reputation, one who had devoted many years of his service to a study of the very engineering problems which had an intimate connexion with the Sukkur barrage project. Personally, he (the speaker) had already given his professional opinion on the scheme in the course of the discussion on Dr. Summers's lecture on the same subject. He then said, on the information given by Dr. Summers, that he was convinced that the project had been hopelessly under-estimated in cost, just as hopelessly over-estimated in revenue receipts, and that there were many serious engineering defects which might conceivably cause an avulsion of the Indus and a calamity of first magnitude. He was, therefore, very anxious to hear the views of Mr. Woods, who had taken no part in the previous controversy. He could have wished that Mr. Woods had been able to convert him to the idea that the project was a good and sound one in the interests of India. But on the contrary, he was only confirmed in his former opinions. It was now quite clear to him that the estimate was over sanguine both in the matter of expenditure and of revenue, and that the barrage and the canals were of such faulty design that the latter must silt very badly. And if an endeavour were made to force water over the silt by further heading up of the water at the barrage, there would be such an afflux above the Sukkur Gorge that the Indus might abandon its present course. No provision was made in the estimate for protecting the river against a disaster of this kind, and avulsion meant grave damage to the North-Western Railway, and to many canals on which the cultivation of a rainless country was dependent. The prospect was consequently very serious, and the only safe course of action was to revert to some such canal as was designed by Dr. Summers in 1910, and to some such revenue forecast as was prepared at that time by Mr. Lucas, Commissioner in Sind, a head being provided for the Rohri Canal on the principles that Mr. Woods had explained. He thought that on the whole, the author had been indulgent to the project, and that he might have been more severe. But at any rate Mr. Woods had prophesied that instead of the work proving productive, it would cause a loss of 68 lakhs of rupees, about £450,000, a year. India was now faced with a very serious budget deficit, the people were complaining of over-taxation, and though the country was very lightly taxed as compared with England, the position was sufficiently grave to cause the appointment of a Retrenchment Committee, with Lord Inchcape as chairman. In view of these facts, he asked whether the present was a suitable time for the Government to embark on a project which could only lead to financial disaster. If it were only a question of pecuniary loss for the sake of the indirect benefits to Sind, his mind would be easier, but even so, it was desirable not to waste money. It was, however, much worse than that. It was not merely a case of monetary loss. The canals as designed would not do the work expected of them; if they did they would water-log the country and injure the health of the people and the quality of the soil, and always in the background was the menace to the integrity of the Indus. He hoped that the Government would take a warning from the facts brought to notice by the author of the paper.

MR. SIDNEY PRESTON, C.I.E., C.B.E., said he was greatly complimented in being asked to join in the discussion. It was perfectly true that a good many years ago he had a great deal to do with Indian irrigation, but he had been retired 17 years, during which time he had not been connected with any of the big schemes for irrigation in India. He thought a more appropriate title for the paper would be "The Sind Canal" instead of "Irrigation Enterprise in India," because the whole of the paper was practically a diatribe against the project which had been sanctioned by the Secretary of State. He was not qualified to offer an opinion one way or the other in reference to the project in question, because he had not seen any of the plans or estimates. It was obviously an extremely complicated problem, and he could not possibly jeopardise any reputation he might have as an irrigation engineer by offering any opinion in reference to it. He had a sort of feeling, however, that as a rule the authorities were right. Dr. Summers prepared a Sind irrigation scheme which was considered by the Secretary of State and by a committee of experts, and it was turned down Subsequently another scheme was prepared, he believed by Mr. F. St. J. Gebbie. The 1920 project was then prepared and carefully considered by all the responsible engineers, including the Inspector-General of Irrigation. It came home to the Secretary of State, was considered in England and subsequently sanctioned, and as far as he knew in due course it would be carried out. He was bound to confess that until he heard what the projectors of the 1920 Project had to say he had a feeling that the Secretary of State must have had some reason for sanctioning the scheme. He was asked to join in the discussion on the paper read by Dr. Summers, before another Society, but declined to do so for the same reason that he refused to give any opinion at the present moment, namely, because he knew nothing whatever about the project. He very much regretted that at the meeting referred to, while a good deal was heard from Dr. Summers and

those who supported him, nobody responsible for the Project appeared and spoke in favour of it. He hoped that would not be the case on the present occasion.

DR. T. SUMMERS, C.I.E., D.Sc., M.Inst.C.E., said he had fully described his project in the lecture he delivered a year ago, and he would, therefore, not repeat the particulars on the present occasion. He only desired to say that Sir Sydney Crookshank, Secretary to the Government of India, had lately put up a defence of the 1920 Project in 12 columns of the *Pioneer*, and at the end of that defence he remarked that the statements of the opponents of the 1920 Project should not "*be accepted without examination in the hard light of facts*" That was all that those who opposed the 1920 Project asked for—an examination of the whole subject.

COLONEL SIR CHARLES E. YATE, Bt., C.S.I., C.M.G., M.P., in proposing a vote of thanks to Mr. Woods for his valuable paper and to Lord Lamington for presiding, said he was sure it would be agreed that the paper would have very important and far-reaching effects. The author, who until recently was Chief Engineer of the Irrigation Department in the Punjab, had worked on the Indus and its tributaries for the best part of his life, and he had just come home from the Punjab with an even later experience than that possessed by the expert committee which reported on the 1920 Project. He hoped the author's opinions would receive the consideration they deserved, as the subject with which the paper dealt was one of vital importance to India.

MAJOR-GENERAL BERESFORD LOVETT, C.B., C.S.I., in seconding the motion, said he had a knowledge of the Indus which went back for 60 years. At one time he was deputed to carry out a project for the protection of the town of Dera Ismail Khan on the Indus, which was gradually being swept away house by house. The protective works erected were successful. In due course he received a vote of thanks from the Government for causing the Indus to retreat seven miles, the town thus being saved; but this shewed that the vagaries of the Indus alluded to by Mr. Woods in his informative address, existed wherever the banks were not solid rock.

The motion was carried unanimously.

MR. WOODS, in reply, said that he would have welcomed more in the way of opposition, or of adverse comment on his criticisms, from those who might be disposed to disagree with them. Mr. Preston had said that it seemed to him that the paper had been rather more in the nature of a diatribe against the Sukkur Barrage Project, in particular, than a review of Indian irrigation enterprise in general.

To that Mr. Woods would reply that, whilst he trusted his criticisms had been couched in language of propriety, it was evident at this juncture that no review of Indian irrigation enterprise would be complete, or even adequate, if it failed to discuss the salient features of the latest manifestation of such enterprise, as embodied in the Sukkur Barrage Project of 1920. The mere fact that the capital cost of this Project was likely to exceed the aggregate capital cost, down to date, of all the perennial canals of the Punjab, was sufficient to justify the most careful examination of its provisions; whilst the extent to which these provisions ignored the teachings of past experience, rendered it all the more advisable for the reader of the paper to draw a clear line of distinction between the successful irrigation enterprise of the past, and that which was likely to be a disastrous failure if persisted in hereafter.

Mr. Preston had pointed to the fact that the Sukkur Barrage Project had been approved of by the Government of India, on the recommendation of its expert advisers, and subsequently sanctioned by the Secretary of State for India; and he naturally attached importance to these circumstances. He (Mr. Woods) had in his paper remarked, however, that this particular Project had been prepared by engineers who had no personal, practical experience of the design, construction, or control of perennial irrigation canals, and, so far as was known, the only engineer with knowledge of perennial canal irrigation who had approved of the Project was Sir Thomas Ward, who had expressly disclaimed responsibility for some of the most important features of the same.

In any case Mr. Woods had criticised the Project adversely on specific professional grounds, and he would welcome any authoritative attempt to meet his criticisms.

The Secretary of State for India had no expert advisers on irrigation matters on his staff, and it was understood that he did not consider himself called upon to judge of the technical merits of an irrigation Project, the funds for which could be raised by the Government of India to his satisfaction. In conclusion, Mr. Woods thanked Sir Charles Yate and General Beresford-Lovett for their appreciative comments; and especially thanked Lord Lamington for again demonstrating his keen interest in Indian public affairs by taking the chair on this occasion. He was grateful also to all those present at the meeting for their patient endurance of his somewhat lengthy discourse.

The meeting then terminated.

SIR JAMES WILSON, K.C.S.I., writes:—

I am not a skilled engineer, and it is thirteen years since I left India; but during my service I had greater occasion than most Civilians have to study irrigation questions, and I have kept in touch to some extent with recent developments,

So I may perhaps make bold to put forward some of the conclusions which I have reached after much thought on this very important subject. I confine my remarks to irrigation in the Indus valley.

In my time there was a tendency to consider irrigation schemes piecemeal, which sometimes led to the adoption of short-sighted views and of schemes which failed to make the best use of the water available in the interests of future generations. I suggest that if this has not yet been done, a very large contoured map should be made, including not only the whole Punjab, but the whole Indus Valley down to the sea, and a great part of Rajputana. On this map should be marked for each of the great rivers the highest point at which the construction of a weir would be feasible, noting (1) the average winter supply, and (2) the average summer supply at that point. Then, disregarding all Provincial and State boundaries, as well as existing canals, mark on this map the limit of possible command from one or other of the rivers, and think what an engineer could best do with the water available if he had a clean slate to work upon. The general position is this—an immense quantity of water flows uselessly into the sea down the valley of the Indus and its tributaries, while the whole of the winter supply and a great part of the summer supply might be utilised to irrigate vast areas of land in and between and beyond those valleys, which only requires moisture to make it fertile; and the first consideration should be—how could this land best be irrigated from a purely engineering point of view? The general conclusion thus reached would of course have to be modified by such considerations as rainfall, quality of soil, present distribution of population, State boundaries and existing irrigation works. But the question should be looked at from the top, and not from the bottom Little regard should be paid to the question of State or Provincial boundaries, and schemes should be thought out with the object of giving the best irrigation facilities possible on the hypothesis that the whole commanded area is under one government Too much weight should not be given to the question of soil, although some soils give a much larger yield under irrigation than others Experience has proved that even the sandy wastes of Rajputana and of the Thal can be made to produce fairly good crops if supplied with a sufficiency of water. Great regard should be paid to the present distribution of population. It may not be so profitable financially, but it is much more beneficial to supply the existing population with water, which increases their prosperity and security in their present homes, than to require them to migrate in large bodies to new country, although this process also should be encouraged so long as it increases the welfare both of the emigrants and of those whom they leave behind.

In order that this policy may be carried out with justice to all concerned, the development of irrigation from the Indus and its tributaries from the Himalaya to the sea, should be placed under the control of one mind, without regard to Provincial and State boundaries. There should be a Chief Engineer for the whole Indus Valley.

In the Punjab the utilisation of the other rivers of the Province should be completed before tackling the great Sind Sagar Project for the irrigation of the Thal from the Indus That scheme will be carried out in time, but it will not pay so well as the other canals, partly because the soil of the Thal is poor, and the silt less fertilising, and partly because it will require a great shifting of population, for which the Province is not yet ready It is better to concentrate for the present on the other rivers, and on the more fertile land for which colonists can be readily found, and to leave the Sind Sagar Doab to be colonised by a future generation of administrators.

The policy of constructing reservoirs in the hills should be continued wherever possible.

Hitherto attention has been chiefly directed to the utilisation of the cold weather supply of the rivers. Endeavour should now be made to make greater use of the immense quantities of water which flow uselessly to the sea during the hot weather and the rainy season This would not only enable a much larger area of hot weather crops to be grown, but would help to raise the level of the underground water-table, and bring it within reach of irrigation from wells It is much better that these great floods of precious water should be stored underground in the Punjab than that it should be poured into the sea.

I am much impressed by the great responsibilities we are incurring in encouraging large numbers of people to migrate from their homes and settle in new villages, whose prosperity will be entirely dependent on the regular working of great canals. If, owing to any cause (whether flood or earthquake or mismanagement or local unrest or invasion from the North-West), the head-works of one of these canals fail, even temporarily, the villages depending on it will immediately, and it may be for a considerable time, lose their crops, and may even have difficulty in obtaining the water necessary for household purposes and for their cattle, and widespread misery may result. To provide against such a disaster, it is necessary that security should be maintained, that the head-works should be kept under the control of the most skilled management available, and that the villages dependent on the canal should be encouraged in every possible way to sink wells, which would enable them in case of such a calamity to draw upon the underground water-table for their drinking water and for the maturing of some small portion of their crops. The best practical means of offering such encouragement is to remit a considerable

proportion of the canal rates chargeable on crops which are matured with the aid of wells, subject to a maximum per well. Endeavour should also be made to develop irrigation from wells on a large scale by means of electricity.

In the course of my work as Settlement Commissioner and Financial Commissioner in the Punjab I became stongly convinced that the rates charged for the use of canal water were much too low, with the result that the owners and occupiers of land which happened to be commanded by a canal were given a much larger share of the benefits of canal irrigation than was their just due; and the proof of this is the very high selling value of canal-commanded land in comparison with that of uncommanded land of the same quality, possibly only a mile or two distant. This is unfair to the owners and occupiers of uncommanded land, and also to the Indian taxpayer, by the exercise of whose credit the money was obtained for the construction of the canal, and who is responsible for the payment of the interest on the loan. The rates charged for canal water, whether in the form of occupiers' rates or land revenue, should be gradually and steadily raised until they approach more nearly to the actual cash value of the water to the owner or occupier of irrigated land.

In the case of a new canal, where the people have not become accustomed to cheap water, the rates charged should, after the first few years, be much higher than the rates at present paid on most of the Punjab canals. This policy will have the further advantage of bringing a new scheme within the definition of a productive public work which would fail to reach that standard if the probable income were estimated on existing rates, and will make possible extensions of irrigation which would otherwise be condemned as financially unprofitable.

When I left India there was in some quarters a fear that developments of irrigation in the Punjab might reduce the amount of water in the Indus available for the irrigation of Sind. In a letter, which was published in *The Times* Engineering Supplement of 22nd October, 1913, I called attention to the fact that a large portion of the moisture which is precipitated over the catchment area of the Indus and its affluents sinks into the soil and is added to the vast underground water-table, which is always found in the great Punjab Plain, at varying depths below the surface, when wells are sunk, and suggested that there must be a constant flow of this underground water-table towards the sea (similar to, but slower than, the surface flow in the river-channels), and that the surplus of this underground flow must ultimately find its way back into the river-channels lower down and join the Indus at or above Sukkur, which is probably the only point at which it can find its way over the rocky barrier, which there appears above ground. I argued that if this hypothesis is correct, the supply to the Indus at Sukkur depends not only on the surface-flow in the river-channels, but also on this unseen underground flow, and that while, by placing weirs across the tributaries of the Indus and diverting almost the whole of their winter supply on to the Punjab plains, the engineers have certainly reduced the surface discharge of the rivers as they pass through the Punjab, yet this irrigation itself, by increasing the seepage over the large area irrigated, has tended to increase the underground flow. It would follow that, even if the whole supply of the Indus and its tributaries during the winter season, at the points where these rivers enter the plains of the Punjab from the hills, were diverted from the natural river-channels over the plains of the Punjab and utilised for irrigation, the winter discharge of the Indus at Sukkur would not be seriously reduced. I am glad to see from the statistics given by Dr. Summers that, notwithstanding the increasing proportion of the winter supply of the rivers which has been withdrawn by the Punjab canals, measurements show that during the last twenty years there has been no appreciable diminution in the discharge of the Indus at Sukkur. I think, therefore, that there is no real ground for hesitating, out of regard for the interests of Sind, to make the fullest possible use of the winter discharge of the Punjab rivers for purposes of irrigation in the Punjab, and that in discussing irrigation schemes for Sind, the possibility of a serious reduction in the quantity of water available at Sukkur, owing to extensions of irrigation in the Punjab, should be left out of account.

As regards the question of irrigation in Sind, I do not know the country and I have not seen the project of 1920, which I understand has been accepted by the Secretary of State in Council, subject to its being shown that the project can be financed to completion without undue difficulty. I have read Dr. Summers's paper, in which he criticises and condemns the proposal that a barrage should be commenced at Sukkur at the same time as the Rohri canal, but I have not seen any answer to his criticism. It seems to me that he gives very strong reasons for deferring the construction of a barrage; and that, even if the Government of India are able to make out a good case for their scheme from the financial point of view, it would be wise to defer the construction of a barrage until irrigation has been considerably developed, and the need of having a barrage at all has been proved by experience. I understand that the rocky barrier through which the Indus passes at Sukkur naturally performs the principal functions of a barrage, and that it may prove possible to irrigate Sind satisfactorily without the great expense and risk of building an artificial barrage. Before venturing a final opinion on this question, I should like to know to what distance the ridge of rock which appears above the surface at Sukkur extends underground east and west of that point, and what exactly

is the danger of the Indus deserting its present course at Sukkur and forcing its way through the alluvial plain further to the east or to the west. The present generation of engineers and administrators would look very foolish in the eyes of posterity if, say fifty or a hundred years hence, the Indus deserted its present channel and left a costly barrage high and dry! I trust, therefore, that even at the present stage, the Secretary of State will appoint a Commission of experts to examine the project of 1920 before allowing the construction of a barrage to be undertaken.

19th June.

POSTSCRIPT.—I have now had an opportunity of reading Mr. Woods's valuable paper, and am confirmed in the view that, in the interests of present and future generations, the river floods should, both in the Punjab and in Sind, be stored in the vast underground reservoir, and so made available for irrigation from wells on a much larger scale than is the case at present. This should be done by a great extension of canal irrigation, especially in the hot weather, care being taken to avoid the evils of water-logging by supplying irrigation to the lands situated at a distance from the present river-channels on a more liberal scale than where the water-table is already near the surface.

I am also confirmed in the view that the construction of a barrage at Sukkur should not be proceeded with until experience has shown that it is really necessary and until further consideration has been given to the danger that such a barrage would increase the risk that the Indus may desert its present channel I understand from Mr. Woods's paper that the Indus, even before it reaches Sukkur, flows at a level considerably higher than that of the valleys on either side. If this be so, further consideration should be given to the interesting question—Why did the Indus desert what would appear to have been its natural channel either east or west of the rocky barrier at Sukkur and choose a course which leads it through that rocky barrier? Endeavour should be made, by borings if necessary, to ascertain what becomes of the great underground flow of water down the Indus Valley towards the sea, when it reaches the latitude of Sukkur; and, before a barrage is constructed, and even before great irrigation works, depending on the present course of the Indus, are undertaken, fuller consideration should be given to the question—What is the risk that the Indus will seek to desert its present channel, and what prospects are there that in that case the engineers of the future will be successful in keeping it to its present course at Sukkur?

28th June.

MR. FREDERICK HODGKINSON, member of the Indian Cotton Committee, 1917, in a letter regretting his inability to attend the meeting, writes:—

"I am particularly interested in the projected Sukkur Barrage scheme, and sincerely hope the Government of India will proceed with the scheme without further delay. It will bring 400,000 acres of excellent cotton land under efficient cultivation, and would grow the American varieties of the longer staple suitable for Lancashire. The estimated cost of £20,000,000 would be an investment which would pay the Government many times over in the increased value of the land. One has only to compare the desolate wastes of Sind with the fruitful Punjab, to realise the benefit derived from similar land under efficient cultivation."

CORRESPONDENCE.

ELECTRIC POWER IN THE FACTORY.

MR S H. ASHWORTH, M.I.Mech.E, writes:—

I have just finished reading, with much interest, Dr. Crowley's paper on "The Use and Advantages of Electric Power in the Factory." I regret that I was not in England at the time it was read, but as I have recently been responsible for the electrification of one of the largest Indian jute mills, I give you my experiences, as they may be of interest to the Society.

The mill of which I was manager until April last is one of the three oldest concerns in Bengal, and I believe actually dates from 1864. The property consists of two mills, the original one, and a modern rope driven mill built in 1897. It is the older mill with which we are concerned at present.

This mill consisted mainly of two buildings, excluding jute go-downs and other subsidiary blocks. In one building were located the preparing and spinning departments, and in the other the weaving and finishing.

Originally each building had its own engine, but in 1891 the old engines were discarded and replaced by one 1600 h.p. engine. The transmission was entirely by gearing.

The factory contained 416 looms.

In course of time it became imperative to replace these 1600 h.p. engines, which had rendered good service for 30 years, and the problem before me was to effect the replacement with as little loss of time as possible.

The only course open appeared to be to electrify the place, and this was decided on.

A power house was constructed close by the mill, and Parsons' turbo-alternators with B.T.H. motors and switch gear were installed. Voltage 500, frequency 50~.

As it was out of the question to couple the motors direct to the shafts which were mostly slow speed, varying from 100 to 220 R.P.M., I decided, after careful investigation of the

various methods of transmission, to adopt the chain drive, and place the motors on the roof of the mill, which was strengthened where necessary to carry the extra load.

Only three sizes of motors were used, viz., 125,100 and 60 h.p. These small units were adopted in order to avoid very heavy chains.

The motors were disposed as follows:—

Batching preparing 7 motors 125 h.p.	875 h.p.
Spinning and warp winding 3 motors 100 h.p.	300 h.p.
and half of finishing 3 motors 60 h p	180 h p.
Yarn dressing and cop winding 1 motor 60 h.p.	60 h.p.
Looms, 4 motors 60 h.p	240 h.p.
Finishing and sewing, 1 motor 100 h.p.	100 h p
Total h.p	1755 h p.

The job took a considerable time to complete, as the bulk of the work of connecting up had to be done at the week ends. It was, however, carried out without stopping the mill for an hour.

The increase in production due to the electrification of the looms and the modernising of the mill generally, has been truly surprising.

In the old days we used to consider anything from 40 to 45 tons per day as a very fine production indeed, but during the year just past, the production has varied from 47 to 57 tons for 432 looms; the smaller tonnage being entirely due to the lighter fabrics being made. As a matter of fact, the yardage was practically constant throughout the year

This represents an increase of about 20 per cent. per loom, of which I consider 15 per cent. to be entirely due to the more even running of the looms.

I have also been intimately connected with the building of two new mills near Calcutta since the war, one of which was able to purchase power, but the other had to generate its own power, and it was finally decided to drive this mill by geared turbines and rope transmission.

The electrically driven mill was arranged with a cable and control gallery on the roof along the centre of the mill. The motors were direct coupled to the shafts, except in the weaving shed, where chain transmission was adopted. The motors are carried on platforms, or suspended from the roof in the case of the small motors.

No individual drive was adopted, except for the pumps, although I am in favour of such a drive for certain machines.

This mill was not completed when I left India, but I understand that it is now working quite satisfactorily.

When drawing up the plans for this new electrically-driven mill, I was impressed with the fact that we could not get away from the steam boiler. We had to allow over a lac of rupees, i.e., nearly £7,000, for boilers to generate steam and heat required in the manufacturing processes of batching, yarn dressing and calendering. In addition to the heavy capital expenditure, this boiler plant takes up valuable space.

I can well imagine that this fact would turn the scale in favour of a steam turbine or reciprocating engine drive in many cases.

It seems to me that electrical engineers might set to work to eliminate the steam plant altogether in jute mills with advantage.

ESSENTIAL OIL AND PERFUME INDUSTRY IN ITALY.

The Italo-English mint is cultivated to the extent of about 600 hectares (1,482 acres) in Piedmont. Calabria and Sicily furnish the "esperidee" (lemon, bergamot, sweet and bitter orange, mandarin, citron, etc), the peel of which furnishes high-grade essential oils, constituting a leading industry of that region, which is only slightly less important than the production of citrate of lime and citric acid, obtained from lemon juice. Lavender, herbs, and plants are plentiful in the western Alps; resinous plants are found in Alto Adige, in north-eastern Italy; rosmary, thyme, juniper, absinthe, and many other herbs and plants abound in Sardinia; aniseed and fennel are raised in Romagna; and the rose, carnation, violet, and other flowers are grown along the Ligurian Riviera. These essences are not only indispensable in the preparation of perfumes, liqueurs, confectionery, etc., but are largely used in pharmaceutical preparations.

One firm, says the United States Consul at Genoa, has succeeded in producing from the Brunner rose of the Riviera, an essence of which 20 kilos was sold in 1919, the first year of its appearance on the market. In order to obtain 1 kilo of this oil about 5,500 kilos of petals, with an approximate value of 4,300 lire per kilo, are used.

The Italian Government, by the decree of November 17th, 1918, exempts for a period of 10 years from the land tax and income tax, lands which are given over to the cultivation of flowers, plants, and aromatic herbs for distillation. This exemption will also be extended for a period of five years to factories which produce essential oils.

Language of Technical Books used in Brazil.—The monthly statistics for April of books consulted in the library of the Polytechnic School in Rio de Janeiro are of interest as showing the relative use of scientific works according to language. The figures are as follows: French, 244; Portuguese, 56; English, 20; German, 2; Italian, 2; and Spanish, 2. Though covering only one month, these figures, in the opinion of the United States Commercial Attaché at Rio de Janeiro, are undoubtedly representative as showing the predominance of French books and French translations of other foreign works in this class of books.

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FRIDAY, SEPTEMBER 15, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

FRIDAY, JUNE 9TH, 1922.

THE RIGHT HON. SIR FREDERICK D. LUGARD, G.C.M.G., C.B., D.S.O., in the Chair.

THE CHAIRMAN said that since Sir Humphrey Leggett had previously read a paper before the Society, he needed no introduction, and his long connection with East Africa had made him widely known as one of the greatest authorities on trade and commercial subjects in that region. He belonged to the distinguished Corps of the Royal Engineers, which had provided the Empire with so many of her most distinguished administrators, prominent both in peace and war. After leaving Woolwich, Sir Humphrey specialised in railway work, and went to South Africa in 1899, remaining there for five years on the staffs of Lord Kitchener, Lord Milner and Lord Selborne. His knowledge of the Dutch language and his conspicuous tact qualified him for the difficult task of Director of the Burgher Land Settlements.

After leaving South Africa he was deputed by Mr. Alfred Lyttelton, the then Secretary of State for the Colonies, to go to East Africa to report on the developments by which the railway there could be made a paying concern. Since that time he had been continuously in touch with the country. In 1907 he returned there to put into operation the schemes he had proposed and for that purpose he founded in 1907, the British East Africa Corporation, being seconded by the War Office. He became so interested in the work that he resigned the Service in 1911.

During the late War he was employed in very confidential duties in England as an agent of the War Office, in close collaboration with his friend Lord Kitchener. His work largely consisted of facilitating the operations of the Belgians in the East African campaign, and for that difficult and delicate employment he was knighted and also received a high Belgian decoration. He visited East Africa again in 1920, and was then able to see the remarkable difference which the change from German to British control had produced in the Tanganyika territory. During his previous visits to the country he had often been able to go to German East Africa, and was on friendly terms with its administrators.

The paper read was:—

THE TANGANYIKA TERRITORY.

By MAJOR SIR EDWARD HUMPHREY MANISTY LEGGETT, D.S.O., R.E.

In expressing my appreciation of the invitation accorded me by the famous old Royal Society of Arts, Commerce and Manufactures, to address you to-day on so interesting and important subject as the Tanganyika Territory, may I say how proud I am to find myself, if only for this afternoon under the orders of our very distinguishep Chairman, Sir Frederick Lugard? Every Englishman who has worked in any capacity in tropical Africa as civilian official, soldier, missionary, or trader, will bear me out when I say that for a quarter of a century, or longer, it has been the cherished ambition of each one of us to find himself in some capacity serving under Sir Frederick. What Mr. Chamberlain was, and for all time will figure in our Empire's history, the Apostle of the British Empire Overseas, that is, and for all time will be, the place of Sir Frederick Lugard in relation to tropical Africa. When he, then Captain Lugard, began his life's work in Africa, the problems, potentialities, responsibilities and rewards that the Dark Continent held in store were either unknown or were the sport of political ambitions among the nations, of unpractical idealism on one hand or of ruthless materialism on the other. Principle and practice were alike undefined. What that quarter-century has evolved, a whole code and creed of practice and of ideal, is set out in clearest form in our Chairman's own recently-published book "The Dual Mandate," an exposition of the mutuality which exists between European civilisation and the backward regions of the African

Continent. He shows on the one hand, the vital need which civilisation has of the tropics, with the duty to develop their vast potentialities to the utmost, and, on the other hand, the lesson that he who takes must give, and give of his best. The older civilisations cannot merely take and hope to go on taking, but they must carry the torch of their own culture and progress, and in every act of administration and commerce, and even of missionary effort, must keep in mind that the world is made for all its inhabitants, not for this or that colour, or section, or nation only.

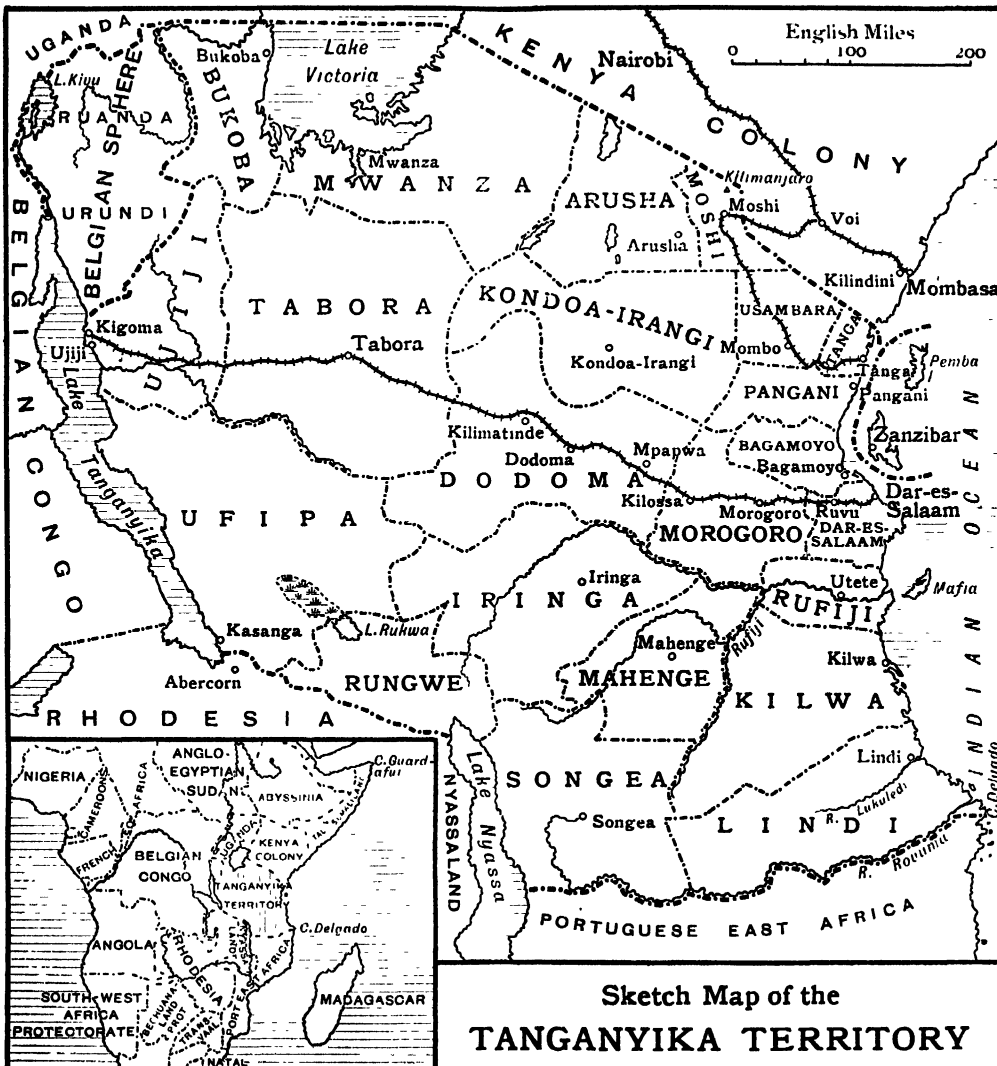
These are truisms to-day. I must almost apologise for repeating the obvious—but 25 or 30 years ago, and more recently than that, the collective consciousness of the European nations had not envisaged the problem, much less agreed upon its solution. But now the work of Sir Frederick Lugard, and of those under him, has so taken root that our present generation may not always recall that the tree is not a hoary oak, but is still a growing plant, and that every one of us has his bit to do in helping that it never becomes stunted nor deformed.

To the vast areas over which this great tree—the British system in tropical Africa—has been established, is now added a fresh country, ex-German East Africa, the size of France and Germany rolled into one. Up to 1914 that country was administered, developed, exploited, on a system differing profoundly from our own. Efficiency, discipline, material progress, were in it almost painfully present to the most superficial observer, yet even the Germans themselves were beginning to doubt whether all was really well. Thinking men among them were uneasy, but changes such as the case would demand must come from the heart, as well as from the head. National temperaments are not readily readjusted. It required the upheaval in the old world of so-called civilised peoples to bring about the change of circumstances that will so profoundly affect this great portion of tropical Africa.

I must attempt, therefore, to summarise to you what the Germans, their Government and their people, had done with and in this greatest colonial possession, from the time of its acquisition by them up to 1914.

Their East African dominion began officially in 1885, in accordance with the sanctions of the Berlin Conference of that year, at which were represented all the European nations having territorial and other claims in the tropical belt of Africa. You will remember how for some years previously, those regions had been the field for a great game of individual grab. Adventurers of various descriptions, respectable and otherwise, from Stanley to Carl Peters, had entered tropical Africa from East and West, making treaties with native chiefs, slave raiders, and almost anybody of local influence, by virtue of which documents of all sorts of rights, territorial, commercial and otherwise, were given just so much reality as it might suit their respective Home Governments to recognise and to support in the international diplomatic field.

None seized its opportunity with more avidity than Germany. The "scramble for Africa," as it was called, led naturally to overlapping of claims, partition of tribes, conflict of economic interests. Unsound frontiers, impossible lines of transport access, and the like, were inevitable. Something had to be done, if disagreements were not to breed warfare in Europe, as well as bloodshed in Africa. Diplomacy was equal to the occasion, at least for the moment, and invented the "sphere of influence." Thus were born in 1885 the Congo Free State, German East Africa, Nyassaland, the Italian Benadir Colony, and the chartered territories of the Imperial British East Africa Company (afterwards the B.E.A and Uganda Protectorates). The Sultan of Zanzibar continued his independent sovereignty of his island kingdom, along with his more shadowy territorial rights along the mainland coast from Cape Delgado on the south to Guardafui in the north. These mainland rights he had offered to Sir John Kirk, who accepted them in trust for the British sphere of influence. The inland limits of the Sultan's dominions were vague in the extreme. Lord Kitchener, then Major Kitchener, was sent in 1886 to unravel them if he could. The knot could not be untied, so he recommended a simple way to cut it, viz., to assume a ten mile strip along the coat line as belonging to the Sultan and all inland of that line to fall to the "sphere of influence" of the respective European powers. Exactly a quarter of century later, in 1911, he visited Mombasa on perhaps the only holiday of his life, and there I had the privilege of hearing him discuss over again with the venerable Sheikh Salim bin Khalfan, his friend of 1886, the outcome of that rough and ready settlement, and the benefits on which the two



were cordially agreed, that had flowed from it.

From 1885 to 1890, the European powers were busily occupying and exploring their spheres of influence, native warfare was almost continuous, and boundary negotiations were set on foot. In 1890 the Sultan's mainland dominions were partitioned. Germany purchased outright for £200,000 the ten mile strip along her 300 miles of coast. Italy did the same. England entered into a perpetual lease for the strip in her zone, which included the Port of Mombasa, on a rental of £17,000 per annum, which is paid punctually to this day to the Sultan's Treasury. Coupled with these arrangements, a composite treaty as between the various European Powers themselves provided for the open door, and equal rights to the nationals of all Powers, in matters of shipping, customs duties and other trade facilities. Within a few years the commercial population of the British ports was 50% German. In the German ports and towns not an Englishman, indeed, hardly any European save Germans themselves, ever became established. There was no law against them, but the non-German simply found an unclimbable wall of obstruction. No British ship called at the German

ports, no British planter or farmer could get the title deeds to his land quite in order. There was no boycott. It just happened so.

Thus, by 1890, German East Africa had its boundaries, its own place in the sun, and started on a career which, until 1905, at any rate, afforded more scope to its military than to its civilian administrators. At an early stage the home people of Germany undoubtedly looked to their colony (as they invariably called it, in rather significant contradistinction to the British use of the term Protectorate for our own adjacent territories) as a field for the expansion overseas of their surplus home population. Britain had founded great overseas communities—Canada, Australia, New Zealand. Rhodes was acquiring more "homes" for England by annexing Rhodesia. Why should not Germany found colonies of the same type to grow into strong outposts of her Empire? The fact of a large resident native population was not overlooked—it could not be—but it could be used. Colonists need labour. So from an early stage the grant of lands to German planters and planting companies became a prominent feature of their system, though from reasons of prudence and economy of administration, these were confined practically to regions within fairly close reach of the coast. It is beyond doubt that the serious native unrest that prevailed in nearly every district, culminating in the rebellion of 1905, was due in large measure to the disregard of native land rights. In the quelling of the 1905 rebellion more than 100,000 natives, men, women and children, were killed or died from the starvation that followed the military operations, conducted as these were with ruthless method and completed by the deliberate destruction of all food supply throughout several provinces. The rebellion itself included the murders of many Europeans, officials, missionaries and traders, and for some years afterwards the districts concerned were "verboten" to missionaries and traders, and were virtually unadministered and unvisited, except by military patrols. These events, as it is perhaps interesting to mention, synchronised with the last of the minor native campaigns in British East Africa, the so-called Nandi War, when the Nandi tribe gave trouble by raiding the cattle of its neighbour, the Kavirondo. Not one white man was even injured, the casualties among the British troops amounted to three men, and to the "enemy" not much more. I was at the headquarters of the British force at Muhoroni on the day when the grand attack was expected to take place. The "enemy" were massed in their position, and, no doubt, some bloodshed would have occurred. Over the wire came an order from the Secretary of State, Mr. Alfred Lyttelton, to the effect that if the Nandi would promise to keep to their side of a certain line, and the Kavirondo on their side of a parallel line 10 miles away, the war should be "called off." They did, and not a shot has been fired there since. Less than a year later I walked through the Nandi country with an agricultural inspector and our personal boys, with no other weapon than a shot gun to shoot guinea fowl.

"Frightfulness," however, had ended native rebellion in German East. The country was divided into administrative areas, which by 1914 totalled 24, of which 19 were civil districts, two still remained under military Government (Mahenge and Iringa), while three, being of an outlying and special nature, were given the status of residencies (Ruanda, Urundi and Bukoba). These latter contained a specially dense population, nearly one half of the total of the whole country (3½ out of 7½ millions and decentralisation in their case was an obvious necessity.

The method of occupation and pacification had completely destroyed whatever existed of tribal organisation. "Divide et impera" was the maxim. For the detailed work of administration the Germans relied upon a system differing profoundly from that which the British system, both in East and West Africa, has invariably adopted whenever the conditions for it were found to exist, namely, the administration of tribal communities through their own chiefs, and, indeed, on the basis of their own ancient laws and customs so far as those be not incompatible with elementary justice and order. The German Government found, on the coast at any rate, the system set up by the Sultans of Zanzibar—absentee lords, so to speak—whereby each district or sub-district was administered by an Arab or Swahali, known as the Akida, a military title not unsuitable to the representative of an alien master interested only in tax collection and the slave trade. These alien officials, working upon an Oriental method, with material inducement to

efficiency, became suitable agents for the German power. Under the German Commissioners of districts, the Akida exercised certain magisterial jurisdiction over the natives, including the power of inflicting corporal punishment, and were even responsible for collection of taxes. A native police force, considerable in numbers and of marked efficiency and loyalty (as the War proved in 1914-1918), assisted the District Commissioner and his Akida or Akidas. That the system was cheap and efficient for the rather short sighted purpose in view, is undeniable. But it carried within it the seeds of future trouble, and was incapable of, if not indeed actively opposed to, the furtherance of native progress. Readers of Gibbon's "Decline and Fall of the Roman Empire," will find parallels almost exact in the administrative systems, based on military power, by which Rome held sway over her outlying possessions in North Africa, which, with her fall, relapsed instantly into savagery, as if the great central power of the Cæsars and all the arts and civilisation of the Augustan age had never been.

Under this system, however, labour was, with increasing difficulty, provided for the plantation system that had been set up. The land grants had been made chiefly in three districts, the Usambara Province, including the fertile slopes of Kilimanjaro, the central district between Ruvu and Morogoro, and, more recently, in the Lindi district at the extreme south of the country around the ports at the mouths of the Lukeledi and Rovuma rivers. By 1912 it was becoming clear that to alienate further lands would result in serious unrest, if not actual rebellion, and further land grants to Europeans practically ceased. Even by then it had become evident that the demand for labour in the settled districts named was far in excess of local supply, and the dangers and difficulties of maintaining sufficiency of recruits, from the not very populous hinterland, were becoming patent, even, indeed, if a sufficient reservoir of labour existed at all in those regions. The entire native population was only 7½ millions. Of this, about 3½ millions lived in Urundi and Ruanda far beyond practicable distance. The remaining four millions in the main body of the country would include, on the usual average, 300,000 to 400,000 only of what may be called labour age. The official statistics of the German Government for 1921, showed that 94,000 native males were then regularly engaged on plantations and mining, 25,000 on railways, harbours, and other Government service (exclusive of military and police), 20,000 in domestic and commercial work, and at mission stations, 15,000 on caravan work, 6,000 police and military, and 12,000 miscellaneous, totalling about 175,000 males in employ at any one time. Allowing for absences and spells of rest, or return to their tribes between periods of labour, such a force continually engaged would take up 75% of the male population of suitable age, even reckoning in the population of the most remote districts, but exclusive of Ruanda and Urundi. The remaining males of labour age, with the old men and boys, and the women, would be none too many to maintain the food supply of the country, and in this connection it is worth noting that the plantation wage and labour system did not include the issue of posho, or rations, which the labourers were expected to buy for themselves, thus pre-supposing a supply from the non-wage labour population.

With these labour resources, the Germans, by 1912, had established certain main plantation industries of high technical efficiency. The latest official figures stated the areas under certain permanent crops to be as follows :—

Sisal Hemp	61,877 acres
Coffee	12,000 acres
Kapok	5,800 acres
Rubber	112,000 acres

The production, as measured by the 1913 exports, was as follows :—

Sisal Hemp	21,000 tons
Coffee	600 tons
Rubber	1,000 tons
Kapok	60 tons

By 1913 the rubber export was already falling, due to the high cost of production from the small yielding Ceara tree, and that industry in East Africa would probably have been dead to-day even had the War not occurred. Had no interruption occurred the sisal output would by now have, in normal course, probably reached 60,000 tons per annum, for very large areas, employing in the planting up much of the labour mentioned, had not in 1914 reached the production stage. Coffee, for the same reason, would probably have reached 3,000 tons, and has, perhaps, suffered less than sisal from the long spell of suspended

activity. But enough has been said to shew that the limits of development of the Colony, on purely plantation basis, were in sight, and that further progress on those lines would have had to await the natural growth of population, coupled with labour saving methods. On the other hand, certain risks were apparent from the fact of an increasing discontent among the natives with the system to which they were being subordinated.

From about the year 1910 appears to date a consciousness on the part of the authorities that it would be necessary to supplement the State revenue by the stimulation of native production of exportable economic crops, the sale of which would increase the native buying power, and that in turn would add to the customs and railway revenues, besides providing outlet for goods from home and profitable enterprise for traders. Until then cotton, which I have not yet mentioned, had been also regarded chiefly as a plantation crop, and under the guidance and with the help of the Koloniale Wirtschaftliche Komitee (the Colonial Economic Society) fair progress had been made, mainly in the coast regions, to a total of some 5,000 to 6,000 bales per annum. German officials visited Uganda, where the crop already exceeded 25,000 bales per annum, grown entirely by natives for their own account, to be sold by them to the highest bidder. The result of this was that a start was made on what may be called Uganda lines, or, indeed, British lines, with the natives in the districts at the south end of Lake Victoria, who by 1914 were producing on the Uganda system at the rate of 3,000 or more bales per annum. The suitability of the coast, especially in the Rufigi delta, the Lindi and Songea districts, and in the central district near Morogoro and Kilossa, for production on this system, was probably not overlooked, but the vested plantation interests and the demand for plantation labour was, no doubt, the reason why native crop cotton growing was not encouraged in those regons. By this system, men, women and children, working their own tribal or communal lands for their own account, it is now reliably estimated, by British experts since the war, that the country has a cotton capacity within a very few years of anything up to 100,000 bales per annum, without interfering with the food supply also grown by themselves for their own consumption, nor with the plantation interests to be resumed on a carefully limited scale.

In addition to cotton by native non-wage labour, the German authorities were undoubtedly eager to increase the production, on the non-wage labour system, of groundnuts, for which the Lake districts are specially suitable. Not only is this product of considerable export value, but it also provides a valuable alternative local food supply. It is only fair to say that their efforts in this direction were checked and limited by the capacity of the British Lake steamers and Uganda railway—the only means of transit from Lake Victoria to the coast—to carry the output. Some 4,000 tons per annum was all that the British railway could carry at that time. The potentiality of the districts is undoubtedly many times that figure.

To sum up, in the last year for which statistics are available before the war, the exports of German East Africa totalled a value of £1,570,915, derived as follows :—

	£
From European plantations ..	729,650
From products partly European, partly native	278,800
From wild products (wax, copal, etc.)	107,000
From semi-wild products (hides and skins)	216,250
From purely native produce ..	102,000

In return the country imported in the same year almost exactly 2½ million £ sterling of goods, made up of half million pound worth of railway and building material and specie, £800,000 worth of cotton goods (almost entirely for native use), and 1¼ million pounds worth of other articles, of which nearly £400,000 was divided equally between rice for native food and other foodstuffs.

To close our summary of this period, let me add that at the outbreak of the Great War the European population was approximately 5,500. The official figures of January 1st, 1913, gave the male population as 3,536, of which Government officials were 551, missionaries 498, military 186, planters and farmers 882, engineers and mechanics no less than 705 (a very interesting figure), while 523 were classified as merchants and traders, with 189 miscellaneous unclassified males to represent the professional and leisured classes. These figures, it should be noted, included Greeks to a total of about 1,200, largely employed as mechanics,

plantation overseers, and on railway work. The Indian population was estimated at 9,000, and was increasing rather rapidly, chiefly as traders in the interior, following up the efforts to stimulate native grown products, for which they provided the market, for without these retail traders, the native products would be in danger of finding no certain outlets.

The railway system of the country was conceived on lines which appear to disclose a wide strategical, as well as a local economic policy. The Usambara line, 220 miles in length, with ocean terminus at the port of Tanga, was commenced in 1893, with projected terminus on the slopes of Kilimanjaro, a region at that date not finally clear of frontier dispute. The line was opened to Mombo in 1905, 80 miles from the port, and the extension to the present terminus at New Moschi, 220 miles from the coast, was opened in 1912. The working of the line was leased to its construction contractors, and by 1914 had not reached a profit-making stage, due, no doubt, to the unproductive character of the zone lying between Mombo and the fertile Kilimanjaro plantation area. This latter region is now in direct rail communication with the British port of Kilindini, over the link line built by our forces during the war to connect with the British main line at Voi, and the natural outlet of the Kilimanjaro region in the future would seem to be through Kilindini. The German Central Railway was begun only in 1905, starting from Dar Es Salaam, reaching Morogoro in 1908, Tabora in 1912 and Lake Tanganyika in 1914, a total length of 780 miles. In 1914 a fine cargo steamer was launched on Lake Tanganyika. The system obviously ranks as one of the main arterial routes of Africa, serving the extensive coast line of that Lake, providing the most direct communication with vast areas of the Eastern Congo. In 1912 the Consulting Railway Engineer of the Berlin Colonial Office described to me Tabora as the Clapham Junction of East Central Africa. He forecasted branch lines from Tabora to Mwanza on Lake Victoria, with a fork running north west into Urundi and Ruanda up to the southern frontier of Uganda. These branches were, in fact, actually approved in 1913, and work was started, the formation being completed for about 100 miles, with 30 to 40 miles of permanent way actually laid when war broke out. He forecasted also an important branch from Tabora to the south west, to connect with Rhodesian territory in the neighbourhood of Abercorn, with intent to tap the Southern Congo and North East Rhodesian traffic. The outflanking of the Nyassaland Lake system was clearly in the ultimate objective. The final achievement of these plans is now in other hands, and we may perhaps express the hope that, under British auspices, they will not be unduly delayed. As a mere illustration of the annihilation of time and distance that these schemes will effect would be the shortening of the present journey from London to Abercorn, say, six weeks via South Africa, to 23 or 24 days via Dar Es Salaam and Tabora.

Somewhat strangely perhaps, little or nothing was done to improve the natural harbours at the two ocean termini, Tanga and Dar Es Salaam. At both ports deep water berthing facilities, although practicable at quite moderate capital cost, were totally neglected. Messrs. Hansing and Co., the agents of the heavily subsidised German East Africa Steamship Line, held a virtual monopoly of lighterage, and landed all inwards cargo at a charge of 7 marks per ton at Tanga, 5 marks at Dar Es Salaam. Export cargo could be and was conveyed to ships by dhows and other privately owned craft, but in 1913 the Government imposed a wharfage fee which, from 1914, was to be collected for Government behalf by Messrs. Hansing, coupled with a remarkable provision that if the services of that firm were not employed in the landing or shipping, a surcharge on the wharfage fee was to be levied. The result could only have been to grant to Messrs. Hansing a virtual monopoly of the port working. All this, of course, is now a matter of history only, but it is permissible to express the hope that the British authorities will allow no similar vested interests to grow up in these important ports to interpose a grasping hand between ship and shore, and thus to levy toll on every import and every export. We may note with interest the recent news that His Excellency the Governor of Tanganyika has directed an enquiry to be undertaken into the cost and other details of providing a deep water wharf alongside which ocean steamers can load and discharge their cargoes.

I will not attempt to describe the War operations which commenced simultaneously with the Great War in Europe. Heroism,

endurance and a splendid loyalty to their salt, were features on both sides, and on both sides it may be said that the War was cleanly fought. But two special points are of interest in connection with our general subject. The German system of semi-military administration enabled them in a very short time to put about 10,000 trained native troops into the field, by the process of calling up ex-soldiers and ex-policemen, who had served their time and passed back to the civilian population. The exceptional number of European officers and non-commissioned officers retained with the regular troops during peace, amounting to no less than 10% of the rank and file peace establishment, provided for the officering of this quadrupled army, and undoubtedly took us by surprise. A further comment that may be made is that until 1914 it was almost generally expected among white men throughout Africa that come what might in Europe, the powers in Africa would not use native troops against each other, but would bide by the result of War in Europe itself.

British civil administration commenced in the Northern portion of German East Africa in March, 1916. Mr., now Sir Horace Byatt, was appointed Administrator of the captured areas, working in co-operation with the Commander in Chief, General Smuts. In March, 1918, the jurisdiction of the Administrator was extended to districts south of the Central Railway. The country remained under martial law, the Commander in Chief being supreme, and it was not until January, 1919, that a Royal Commission was issued appointing Sir Horace Byatt as the supreme authority. Under the Versailles Treaty of 1919, Germany renounced in favour of the principal Allied and associated powers, all rights to her overseas possessions, including German East Africa, and this was followed by the decision of the Allied powers to confer upon Great Britain a Mandate to administer what had now become ex-German East Africa, in accordance with certain principles laid down by the covenant of the League of Nations.

It will be remembered that the Belgians proved themselves good and loyal Allies in the East African Campaign. Their operations taking place from the north and east, it came about that they found themselves in military occupation of the Eastern portion of the country from Lake Tanganyika as far as Tabora, besides the North Western districts of Ruanda and Urundi. In the settlement of Mandates, it was decided that Ruanda and Urundi should be placed under Belgian Mandate, and these important areas are therefore now finally dissociated from the Tanganyika Territory, and are, as a matter of fact, being administered under the Governor General of the Belgian Congo. The Belgian Authorities continued to administer the zone between Tabora and Lake Victoria for some time after the Peace, but this area has been gradually handed over and is now entirely under British Administration.

It would take an international lawyer, which I am not, to define to you the precise juridical status of a mandatory country. Just as diplomacy at the Berlin Conference of 1885 invented Spheres of Influence to meet a situation that was without precedent, so did the ingenuity of man overcome the obvious difficulties that were seen to lie in the way of out and out annexation of this or that German possession by this or that of the victorious allies. The principle underlying the Mandate system is, however, clear. It is laid down that the country under mandate shall be so administered that the Mandatory Power shall promote to the utmost the material and moral well-being and social progress of the inhabitants, that there be ensured to all Nationals of States, members of the League of Nations, equality of opportunity in the economic, commercial and industrial spheres, with freedom of transit and navigation, and in short, that the potentialities of the Mandate country shall not be monopolised to the benefit of any single power. Subject to these conditions, which, indeed, have been inherent in the British system in the purely British owned Territories of Africa, there appears nothing material to distinguish the position of a mandatory administering power from that of an out and out sovereign. The draft of the Mandate for ex-German East Africa has been published and includes the points I have just mentioned. It is understood that it has still to come before the Council of the League of Nations for final approval. A curious problem undoubtedly exists, for which diplomacy appears already to have found a solution. America, though a signatory of the Versailles Treaty, never ratified that Treaty, but concluded a separate peace with Germany. The renunciation of her Colonies to the principal

allied and associated powers included America, in the first instance, among the latter, and had she ratified the treaty, she would have become a party to the mandate. Being outside the treaty, America is no longer one of the powers on whose authority the Mandate has been, or will be, definitely based. This difficulty seems to have been overcome in the case of Palestine by means of a separate Treaty between America, herself and Great Britain, the mandatory power, and doubtless a similar instrument will be necessary in the case of ex-German East Africa, and it can, no doubt, be assumed that such a Treaty would afford to American Nationals the same complete freedom of opportunity that is to be enjoyed in the country by the Nationals of the other Treaty powers.

Six months after the ratification of the Peace Treaty, and the coming into effect, *de facto*, if not *de jure*, of the Mandate, a British Order in Council was promulgated constituting the office of Governor and Commander in Chief of the Tanganyika Territory, which thus became henceforward the official name of the country, and Sir Horace Byatt, K.C.M.G., was appointed to that position.

Much spade work had been done in examining the condition of the country, more particularly in providing by means of district political officers for the control and administration of the native population. The German staff had been swept away, but the Arab or Swahili Akida, already explained to you as wielding so much of the detailed administrative power under the German District Commissioners, were in many cases still on the spot. Their local knowledge was, of course, invaluable, and although some, perhaps, might not exactly welcome a change of system under which their individual powers were bound to suffer material check, as a rule they accepted the situation and were glad to transfer their allegiance. It is obvious that the call upon tact, energy and insight into native character, required of the British District Political Officers by the abnormal conditions that existed, must have been immense, and the fact that the change over from German to British Government throughout so vast a country, after all the cataclysms of war, was accomplished without serious trouble among the natives, speaks volumes for the governing capacity of the Englishmen concerned. Much even now obviously remains to be done. Tribal organisation, where possible, is the obvious goal, and as a step towards this, Arab or Swahili alien Akida will, no doubt, be gradually replaced by chiefs and headmen emerging from the body of each tribe or community. Native law and customs will also emerge, differing doubtless in the various parts of the country, but adopted where suitable to the various sections of the native population, so far as compatible with justice and order. When once cohesion within a community, be it village, group of villages, or tribe, has taken root, the problems of administration will become greatly simplified, and with them, the success of economic development, technical education, hygienic measures, and the like, will rapidly advance. Progress in all these directions is already clearly visible.

The fate of the lands that had been allotted by the old German Colonial Government to Germans and other Europeans, presented an immediate problem, which was much complicated by the destruction or disappearance of title deeds and other records during the War. Under the Reparation and Enemy Debt Clauses of the Versailles Treaty, all private property of enemy Nationals in the ex-German territories, became ceded to the Allies, compensation to their original enemy owners to be made good by the German Government. The first obvious difficulty was to ascertain the ownership of each plantation or other land that had been in European occupation. Some were the subject of claims by Greeks, Swiss and other non ex-enemy people. As an ex-enemy title to any plantation area, trading site, building or other real property becomes finally proved, after exhaustive examination and test, and due notice of appeal allowed, the property is proclaimed in the Government Gazette as falling within the disposal of the Custodian of Enemy Property, acting under the administration of the Mandatory power. From time to time, lists of these properties are being advertised for sale, and they may be purchased from the Custodian at open auction, or by private treaty, by any except ex-enemy Nationals. The buyer, moreover, is called upon to enter into an undertaking that his purchase is neither directly nor indirectly for behalf of an ex-enemy. By this procedure, town properties at the chief ports and other centres, have already largely passed into the hands of British and Allied Nationals, and the similar

disposal of plantation areas has been proceeding during the past year. Some complaint by would-be buyers has made itself heard as to the comparative slowness with which the operation is being carried out, but seeing that the Mandatory power, i.e., the British Empire, is guaranteeing to the buyer an indefeasible title to the property, it appears to be only commonsense that no such sale should take place, or title be granted, until the original enemy ownership has been established by the utmost proof and test. The Torrens System of Land Registration has been, or is being, set up in the Territory, and buyers of these lands will thus enjoy the facility of registration, with all that it implies, in the security of occupation and ability to sell, lease or otherwise dispose of their interests for their own behalf, with the minimum of legal expense.

Before leaving this subject of European land holding, I venture to suggest that the difficulties that the Germans were beginning to apprehend in the matter of labour supply, should not be overlooked. If it be true that more land was granted before the War than there was labour, on a voluntary system, adequate to develop, it would seem in the highest degree unlikely that the same total area could safely be transferred to Europeans at the present moment, when the country has not recovered from the disturbance of War. The plantations, moreover, now require exceptionally large labour gangs for their restoration after years of jungle growth. It will be surely disastrous to the buyers themselves, if unduly large land holdings are purchased in the hope of sufficient labour being forthcoming, and then to find their operations checked, and their capital rendered partly idle by shortage of man power. Anything approaching the compulsory or semi-compulsory methods adopted by the Germans must always now remain out of the question, but it may not be too much to suggest that a moral responsibility is likely to be argued as attaching to the Government, if by selling these lands and thus inviting European occupation on too large a scale, a labour shortage should make itself felt in the future.

Side by side with this matter of land disposal and the slow but sure restoration of the valuable planting industries, more particularly in sisal and coffee, the Tanganyika Government has been giving its attention to the establishment of stable crop production by the natives on their own land and for their own account. More particularly, attention has been paid to cotton and ground nuts, while not neglecting articles of local food consumption, such as rice, maize and millet. The world depression of the past two years has been a heavy handicap in these matters. Cotton, when grown, could not be sure of a market, and the same could be said of the collecting of hides and other natural products of the country. What has been proved, however, is the extreme readiness of the natives in practically every region to accept the advice of the district officers and to cultivate with a real energy. Seed has been asked for in increasing quantities, and it is on record that cattle owning tribes even show such enlightenment to their own interests as to request the Government to supply high grade bulls by which to improve their herds.

The Germans in later years had been devoting increasing attention to the education of the native, chiefly on the technical side, probably not without recognition of the fact that until a skilled class could be created among the indigenous population, the influx of orientals for clerical and subordinate technical work could hardly be avoided. Considerable headway has been made by the British Government and the Missionary Societies, in restoring the schools, and the figures of attendance are gratifying. Before the war, no less than 1,832 schools were being conducted by the Missionary Societies, and 99 by the German Government, and the number of children on the registers of attendance exceeded 100,000. While quite possibly some rather forceful persuasion was at work, the figures are so large as to illustrate the keenness of the African native to take advantage of the opportunity given him by schools to advance his future prospects.

Among the more material problems of restoration, none could be more important than that of restoring the efficiency of the railway system, which suffered serious damage during the war, both to track and to rolling stock. In all these matters much has been done, but much remains to do. Traffic is, at any rate, being regularly forwarded over all the lines of railway, as mentioned earlier in this paper, but unless the carrying capacity be considerably increased by the further restorations still to be done, and by the provision of further rolling stock, any material increase in the

production of the inland districts would meet with serious check by the difficulty and delay in finding an outlet to the coast. In the same connectiôn, I have already mentioned the need for improved harbour equipment and deep water berthage.

Before closing this review—necessarily inadequate for so big a subject—it is worth while to notice the generous financial provision which has been made, and further provision forecasted by the Imperial Government towards the restoration of this derelict country. I believe I am right in saying that for 1920 the British taxpayer provided £330,000, for 1921 something like £800,000, and that in the Imperial Colonial Office estimates for the current financial year another sum exceeding three quarters of a million pounds is asked for from the British taxpayer. These sums, so far as I know, are an out and out grant by the United Kingdon, to what we may term its adopted orphan child. No interest, no tribute, no monopolistic rights from the fructification of these immense sums are asked for, or made a condition of the grants. If ours is a country of shopkeepers, at least we may urge, with pride, that the shopkeeper is not afraid to put his hand in his pocket when it is a case of "noblesse oblige." The taxation of the natives and the trade taxes upon Europeans in the territory remain at the low pre-war level at which they were left by the Germans in 1914, the deficit unavoidable in the administration of the country being met from the grants of aid that I have mentioned.

In this paper I have not attempted to describe to you the physical and other features of the country—rainfall and other details—for I have felt that at this somewhat early stage in its history under British administration the great and salient feature is that of the implanting of the British system of native and land administration upon a country hitherto governed on other lines. Side by side with this general matter, I have tried to indicate the main directions in which economic development is likely to proceed in the future, and the lines of railway and other communications which form the arteries of the country, besides connecting it with adjacent territories. Let me say that probably all who know the country will agree that it is certainly not suited, except perhaps in one or two comparatively small patches, for European settlers on colonial, *i.e.*, farming and ranching lines. It is rather low lying, rarely exceeding 4,000ft., essentially tropical, and by no means a health resort. It is, therefore, a country clearly destined for development on a carefully balanced combination of plantation development, side by side with native economic crop production. There is no reason why these two avenues of development should be incompatible with one another. On the other hand, they can definitely support each other, but I must repeat that success and the absence of friction depend upon a careful proportion being observed between the degree to which each is stimulated and encouraged. There is sometimes not much practical difference between the grant of facilities and actual official encouragement, since those to whom the facilities are granted may not unfairly argue that they should not have been granted them had it not been intended that they should be fully effective. Practically all development in tropical Africa depends ultimately upon population. Area is counted by square miles, not by acres, and with a population of not more than 15 to the square mile, it depends only upon good administration to ensure that development, both by plantation and by native production media, will not be checked through lack of area.

I have barely outlined the great task undertaken by the British Empire in discharge of the trusteeship conferred upon it by civilisation. Time does not admit of discussing the hundred and one details with which the hands of the Administration must be daily engaged. Mineral exploration, for example, has been regulated and encouraged by the enactment of a broad mining law and the grant of prospecting facilities. Coal, which the Germans had failed to locate, has been found, but I gather that the quality is not yet ascertained. Obviously the importance to the whole of Eastern Africa of such a discovery, if confirmed, will be immense. Transit facilties for the Congo traffic have been organised, with arrangements for "in bond" transmission of goods in both directions. Township affairs have had attention, with the setting up of municipal committees at Dar Es Salaam and Tanga and elsewhere. Medical, sanitation and research departments, have been organised. Agricultural, mining and survey departments are at work. Posts, telegraphs and coastwise shipping services are restored.

The intricate matter of the change over from German to British currency has been accomplished.

All this, be it remembered, has had to be done when the whole world was out of gear, and the demand for expert and trained administrators was never so great. Unlike the re-organisation of the Transvaal by Lord Milner, after the South African War, it was not the question of taking over from an ex-enemy Government already functioning. Nor could it be quite a matter of creating a new organism from the egg. True, the egg was there, but it was badly addled. A new egg has had to be laid and hatched, and we, as Englishmen, may feel proud that the chicken bids fair to grow up a strong and healthy bird.

May I just say a word respectfully to those, for there are some, who are disappointed that progress has not been even more rapid, especially in commercial activity, and land development? Some complaints of official lethargy, and even of obstruction, have been made and published by a few individuals in the Territory. Their remarks have been carefully noted in Germany, where there are many only too ready to turn them to account. About a fortnight ago, Dr. Scholle, the Director of the German Colonial Society, referred to these complaints, at a meeting held, I think, at Leipzic, which was attended by most of the ex-Governors of the old German Colonies, among them Dr. Schnee, ex-Governor of East Africa. What better proof, said Dr. Scholle, can the world need of the justice and necessity of the restoration of her colonies to Germany, for which event, he added, every loyal German must never cease to work, than the fact that even British residents in Tanganyika Territory are complaining of the British Government? How much better, he implied, would matters be if the Germans resumed the administration. Now, I hold no brief for the British Governor of Tanganyika and his colleagues, save that which every Englishman should hold, viz., to support in every possible way, those men of our race, and those principles of our tried and proved system of African administration, that have kept the name of Great Britain clean before the world. Those men are laying the foundations of a great British dependency. The British East African group of countries, of which the ex-German Colony is now a definite component element, has a population of 12 million people. In 1822, the United Kingdom held one million less than that. To-day these Islands hold nearly 50 million inhabitants. With the Pax Britannica, the British pharmacopeia and good Government, that British East African group of African countries will, in a hundred years from now, have probably a population of 50 millions. And what is 100 years in the history of the world? What, if Great Britain proves worthy of her place, will 100 years be in the history of the British Empire? The Roman Empire in Africa covered 600 years of time. In less than half that period, tropical Africa will have her hundreds of millions of British native subjects. Will they be a blessing to the world, or a curse? There can hardly be a midway result. What is done during the next few decades will probably decide the answer. Great, indeed, is the responsibility that rests upon the present generation. Let us, therefore, wholeheartedly support those men of our race who are carrying the torch, cheer them in their task and thank them for their devotion.

DISCUSSION.

The Chairman (Sir Frederick Lugard) said the meeting had had the pleasure of listening to an extremely interesting paper, full of facts and the stored experience of a man of affairs, who was a competent critic. He thought everyone would agree with the general conclusions the author had arrived at; personally he heartily agreed with practically everything that Sir Humphrey Leggett had said. He had described the German Akida system, contrasting it with the method which had superseded it under British rule. A similar system had formerly existed in the Mohammedan States of Nigeria, where the rulers employed "Jekadas" to collect taxes and forced labour. Bad as that system was in Nigeria, it was a thousand times worse when enforced as in German East Africa by a European power with organised troops. What the rebellion against that system meant was shown by the statement that in 1905 something like one hundred thousand men, women and children were done to death.

The second conclusion at which the author arrived was that to encourage the native to be a producer was better than making him a mere wage-earner, in the position of a serf or slave. Under the system of native production, the natives would gradually emerge from that bondage of slavery to which for so long they had been accustomed, and gain the idea of independence and freedom. Apart from the

moral aspect, he thought that the system of native cultivation was sound economic policy. As Sir Humphrey had remarked, the Germans had been forced to admit that that was the case, and to adopt that system to some extent. For the success of such a policy it was essential that the Government and the merchants should co-operate.

In this connection he might say that if all the big estates formerly owned by German planters and now advertised for sale were sold to European purchasers, it would seem as though the British were perpetuating to some degree a system which they condemned when it was practised by the Germans. If the supply of labour was insufficient under German rule, it would be much more so when the estates had to be restored to the condition in which they were before the War. When, in addition, the author estimated that an annual production of 100,000 bales of cotton should be looked for, the difficulties in securing labour for the big estates as well could be realised. He had no doubt that that had been considered by the Colonial Office, and he hoped that some of the estates would be restored to the natives, only such a number being sold to European purchasers as could be adequately supplied with labour. In that matter Sir Humphrey was evidently in agreement with him, for he said that the plantation interests should be resumed only on a carefully limited scale.

It was mentioned in the paper that there had been a good deal of criticism of the local Government and of the Colonial Office for, it was said, going too slowly. The British taxpayer had, during the last three years, given something like two million sterling for the development of the Tanganyika territory, and he thought everyone would agree that the present was not the right time for trying to push ahead too fast.

Under the Mandate system, equal opportunity in trade and commerce was given to all members of the League of Nations. Personally, he would like the Germans to go back to their old country as traders so that they might see how matters were managed under a different system of rule. He wished to ask whether anything was being done about what were called "mean whites." It had been said that of the 5,000 Europeans who were present in the pre-war period, 1,200 consisted of Greeks, who were hardly considered white men by the Germans. He had come across the same class of Levantine Greeks in Abyssinia, where they had introduced distilleries and a low commercial morality. He hoped that some steps would be taken to prevent the entry of that class of European into the territories inhabited by primitive races.

Sir George C. Buchanan, K.C.I.E., M.Inst.C.E., said he gathered that there was now an opportunity of starting with a comparatively clean slate in Tanganyika. Much depended on the initial policy. He thought every one would agree that there was ample room for development, both by the plantation system and by natives working on their own land. Fortunately, Tanganyika was not hampered by the delusion which existed in Kenya, that it was what was termed a "White Man's Country." The first essential of a white man's country was a climate in which the white race could breed without deterioration and where children born and bred in the country would grow up as strong and vigorous mentally and physically as their grandparents. He understood that that essential was unobtainable in the tropics, where the climate, though cool in the hills, was not temperate. If, then, it was decided to encourage and stimulate the native producer, as was done in India, Uganda, and on the West Coast of Africa, as a natural corollary, he must be given an inalienable right to his land. In Kenya that was not yet the case, and at a recent meeting of the Convention of Associations, where native affairs were discussed, it was stated that there was no greater source of native unrest than the land question. The natives had no security; time and time again the Government had promised not to take any more land, and as often the promise had been broken. It was to be hoped that that would not occur in Tanganyika. In the matter of the development and equipment of the country, railway and road communications and port facilities came into the forefront. For those essentials large sums of money were required, and the question naturally arose: Where was the money to come from? The author had said that large grants in aid had been made by this country; in other words, the already over-taxed British taxpayer was being called upon to pay for the upkeep of countries about which the majority knew little and cared less. The railway was being run at present at a dead loss of something like £100,000 a year, and it was unlikely to pay until further developments took place. The ports required developing on modern, but not necessarily extravagant lines. He hoped a lesson would be learned from Kilindini, where about one-and-a-half million pounds was being expended on a two-berth wharf. The Colonial Office would be well advised if they invited the assistance of private enterprise to develop the railways and ports of Tanganyika. Lord Inchcape had said in a recent speech that during the investigations of the Geddes Committee he had been more than ever satisfied that it was a fatal mistake for any Government to embark in trade or business of any description, and that the proper and only functions of a Government were to maintain law and order, provide adequate defence, exercise rigid economy and tax all sections of the community fairly. Unfortunately, Governments did not always take that view, and pre.

ferred Government control, however expensive. A tendency to public extravagance was one of the unfortunate legacies of the war. Schemes were promulgated because they were bold and appealed to the imagination, regardless of ways and means, and when the bill came in it was too late to remedy the evil. Nothing was easier than to spend other people's money, and the bringing in of private capital for development would have a sobering influence.

MR. ALFRED WIGGLESWORTH said that having had an opportunity of visiting Tanganyika before the War and studying the situation there, he could vouch for the immense labour which Sir Humphrey Leggett must have performed in getting together so many facts regarding the German method of administration, and in giving an up-to-date statement as to the situation of the Colony under British rule. There was, as he had said, considerable criticism of the Local Government, especially in Tanganyika itself. He thought those who were responsible for that criticism had forgotten, to a large extent, the difficulties under which the Government laboured in taking over the Colony, which had lost all its traditions and all its records. Those who had previously administered the Colony had left before the British took it over, and the legal system had entirely broken down. What rendered the task more difficult was that owing to the Mandate system not having been properly evolved until almost two years after the Colony was taken over, it had to be administered without any Mandate whatever. The author had briefly discussed the meaning of a Mandate. The authorities admitted that even under a properly constituted Mandate, the King had no power to appoint judges; he could only appoint them for territory administered by the Crown. That caused an interminable delay and a great deal of legal argument. During the *interregnum* the Greek gentlemen to whom the Chairman had referred took every advantage of the situation and put the commerce of the country in a very serious condition. The clock was thus set back by many years. It was only now when the Courts had been properly constituted, and the estates, to a large extent, had been assigned to responsible people, that headway was beginning to be made. The Chairman suggested that some of the estates should be reserved for the natives, but he could not see how they were going to find the money to buy and carry them on. Most of the estates that were being sold were 10,000 to 20,000 acres in extent, with machinery, equipment and organisation only workable by Europeans. The Germans would not allow anyone to buy an estate until he obtained a certificate to state that he had made arrangements for an adequate supply of labour, and that he had raised the necessary capital for the development of the land within a certain number of years. That method was one which could very well be adopted by the present Government, so as to prevent the leasing of land to people who would only hold it for a speculative rise in value, or who might not have the necessary funds for development. In alienating to the Belgians the two provinces in the north west corner of the territory, a very valuable asset had been allowed to disappear. The provinces in question were amongst the richest in the whole territory, and, as Sir Humphrey Leggett pointed out, contained three-and-a-half millions, or approximately 50 per cent. of the population of the entire country. The Germans had been looking to those provinces as a recruiting area for native labour.

The fact that no British ships called at German East African ports was due to a useful arrangement between the Union Castle Line and the German Lines not to touch each other's territory. Prior to that agreement the Union Castle boats called regularly at Tanga and Dar-es-Salaam. The Germans had a system of small coasters calling at the little isolated ports which ocean liners could not reach and picking up cargo, which was transhipped without having to be put into lighters. That was of enormous importance and might well be adopted at the present time. African produce was being sold at the lowest possible price, and unless every penny was saved on manufacturing and transit, profits could not be made, and without profits the development of the country could not go on. The country had depended far too much on grants-in-aid from Great Britain that could not be continued indefinitely. The author stated that the total German exports from the province amounted to approximately £2,000,000. He was rather frightened to find, therefore, that the Government expenses for the year 1921-22 were £1,920,000. The German expenditure was much less than this amount. The territory had been set back very considerably by the War and delay in reconstruction, and it would be a very long time before it arrived at the position which it occupied in 1914. If it was going to show results that would justify British merchants in spending money to develop it, the expenditure on administration must be enormously reduced. If Tanganyika was to be properly developed, wages would have to be adjusted and would have to come down to a point which would render competition possible. The natives could not start plantations on their own account. If they were handed cotton seed, they would plant it and hand over the produce, but they could not grow sisal, coffee or any large products. The splendid Biological Institute at Amani, two or three thousand feet up in the hills, did extremely valuable work before the War. It was thoroughly well-organised and had been of

great assistance in guiding the German planters along successful lines. It was half the battle of successful tropical development to know what was going to succeed and what was not, and ruthlessly to cut out all failures.

SIR JAMES CURRIE, K.B.E., C.M.G., said Sir Frederick Lugard had told them that one of the first things to be put right was the existing land system. It occurred to him that the Chairman had gone rather farther than Sir Humphrey had intended with regard to the plantation system. He would like to know whether he was correct in that surmise or not. He entirely agreed that native ownership and native development must form the basis of the Colony's progress, but it was important not to overlook the fact that every well-run plantation under European management was a fine technical school, to call it nothing else. He did not think that in any country an unlimited system of small holdings, and a complete absence of large estates, was desirable. In Vanderlip's book on European Problems the extraordinary fall in production and agricultural efficiency in various parts of Eastern Europe was ascribed very largely to the smashing up of big estates and the universal introduction of peasant proprietorship It was quite possible for the pendulum to swing too far in either direction. He did not believe that South Africa would ever obtain her maximum production of staples until she scrapped the policy which obtained there, and rendered it possible for the native to settle on the land with more freedom than at present That did not persuade him, however, that a complete elimination of all large estates would be opportune or wise, and he hoped that a certain number would always remain in existence. A great deal had been heard about the danger of high expenditure, but surely that depended on what the objects of that expenditure were He had the pleasure of hearing the President of the Board of Trade say the other day with regard to the creation or re-creation of potential markets for the export trade of this country that he would much sooner put money into our own colonies than continue fooling with policies of reconstruction in Eastern Europe. He would like to ask whether the great bulk of the population of Tanganyika territory were Mohammedan or Pagan?

MR. DONALD MELLOR, F.R.G.S., said he had to deal with travel in Tanganyika Territory and was especially familiar with the railways. It was remarkable that the central line from Dar-es-Salaam to Kigoma was not thought so much about as it ought to be. He believed that at the present time there was an enormous traffic going along it to the Belgian Congo, and it was natural to suppose that there would be a certain amount of traffic going back over that line from the Belgian Congo until the Belgians properly developed lines of their own towards the Atlantic. He would have liked to hear a little more about the country between Victoria Nyanza and Tabora. He did not know whether a road existed between Tabora and Mwanza, but he had heard lately that there were two routes between those points. That was of great interest from a traveller's standpoint, because several people had made journeys from Cairo to Cape Town via that route. One could go from Tabora to Cape Town by rail and steamer all the way, and it was possible to go from Dar-es-Salaam to Cape Town by that inland route in 25 days. It was of interest to note that the Belgians had just launched a 350-ton steamer on the lake, which would make things better for passenger traffic and trade generally. Something had been said about the grumbling out there. He hoped that the railways would, as far as their resources went, develop the line and the rolling stock, and bear in mind that to put too high rates on the traffic would certainly be disadvantageous to the development of the colony. Many people forgot the work that the men out there were doing and the influence they exercised over the natives, an influence which had raised the British name wherever British people went. He trusted the officials in Tanganyika Territory would not be altogether forgotten.

SIR HUMPHREY LEGGETT, in reply, said the discussion had been one of the most interesting he had ever listened to. With regard to the Chairman's question as to "mean whites," he understood there was a financial condition attaching to immigration which was strictly enforced, and he believed that at the present time an enquiry was made into antecedents if there was the smallest doubt as to the desirability of any individual. The only remedy, he thought, was to make it known as widely as possible that the opportunity of "getting rich quick" did not exist in East Africa. If that was done such people would not come. Everyone would agree with Sir George Buchanan's remarks on the openings which should be given to private enterprise. Subject to proper supervision, it was most desirable that private enterprise should be encouraged. Such concessions as a monopoly of the lighterage at the ports, which the Germans granted, were not desirable, however. There might be special circumstances in a mandated country such as Tanganyika which demanded exceptional consideration, in view of the fact that the raising of loans on the security of the country itself might not be feasible for some time to come; it was undesirable that the country should be held back by absence of capital for necessary public works. Sir George Buchanan had mentioned the matter of land set aside for natives. Personally, it was his view that the whole area was a native country. He detested the expression "native reserves"; he thought

that land not in tribal occupation might be set aside at the disposal of the Central Government, so that it could not be taken up and misused by any one—white or black—but the idea of delimiting native reserves and saying all the rest was European was putting the thing the wrong way round.

With reference to Mr. Wigglesworth's remarks, he agreed there were many juridical difficulties appertaining to a mandated country, such as right of appeal to the Privy Council and so forth. These must take time to settle. Mr. Wigglesworth also mentioned the subject of reserving land from sale, and asked how it could be sold to the natives. If the Chairman's proposal were adopted, as he hoped it would be, and the whole of the alienated lands were not sold, it did not follow that the Government would sell the land to the natives. If the lands alienated amounted to, say, one million acres, and it was decided that not more than 750,000 acres should be resold, the remaining 250,000 would remain in the hands of the Mandatory Power. The question might then arise as to the value of that unsold land being credited to the Reparations Fund. He thought the difficulty might be got over in the following way. Some of the land grants had been immense, far greater than were likely to be fully used, and some of the more remote ones might, therefore, be divided into two, and only the more valuable portion sold Three or four thousand acres could be lopped off a ten thousand acre estate quite easily, and that residue would then have a low value and might remain the property of the Central Government without payment. He was of opinion that economic balance was likely to be achieved in a very short time If it became a question of pushing either the plantation interest or native-grown produce, he thought preference should be given first to the latter, as quicker returns would be obtained therefrom during the next two or three years, while the plantations were being restored to their former output capacity. He agreed that the Institute at Amani was most valuable. The British Government had done their best to keep it in being, and had retained some of the German scientific staff there until British experts could be sent to replace them, thus avoiding a break in continuity. Sir James Currie had asked whether the Chairman had not gone further in the matter of native crop development than he himself intended. He thought, as far as words were concerned, that was perhaps the case. It should not go out as the considered opinion of the meeting that it was wise for a country like Tanganyika to depend on native production only. He agreed with Sir James that plantations were technical schools of the highest value, and, further, they produced crops of the greatest value to the Empire and raw materials of tremendous importance to the material requirements of this country and of the world, which could only be obtained on the plantation system. Not one ounce of sisal would ever be produced if native production alone were relied on; it required high organisation, technical skill, elaborate machinery and plantations worked in the most up-to-date manner. A carefully balanced combination of the two methods of production was the thing to aim at. Sir James Currie had also asked about the religion of the natives. There were 7½ million natives in German days, and there were now about 4 million under British rule. The German statistics showed 280,000 Mohammedans, and that included Swahili and the population on the coast; the remainder were Pagans or Christian converts. A German circular found after the war, showed that the Germans had told their District Commissioners to encourage the native chiefs to become fond of pig flesh, in order to prevent the propagation of the Mohammedan religion. With regard to Mr. Mellor's remarks, the road from Muanza to Tabora was open up to the year before last, and at that time was quite suitable for motor-car traffic. He believed it had since become somewhat overgrown, but it would no doubt be re-opened again, as it was an important line of communication. Mr. Mellor had mentioned a 350-ton steamer put into commission by the Belgians. Before the war the Germans had a 1,000 ton steamer on the Tanganyika Lake. The British Navy sent it to the bottom, but fortunately the bottom was not very deep, and within the last fortnight money had been promised by the British Treasury for raising and restoring that steamer, and it was hoped that within the next six months she would again be in commission under the British flag.

MAJOR BLAKE TAYLOR, C B E, proposed a vote of thanks to Sir Humphrey Leggett for his very able paper, and to Sir Frederick Lugard for presiding. The thoroughness with which the former had prepared his paper was what one would expect from one whose heart and soul were in the development of Africa.

ADMIRAL DE COURCY HAMILTON, M.V.O., seconded the motion, which was carried unanimously, and the meeting terminated

TOBACCO GROWING IN THE BRITISH EMPIRE.

A special correspondent of *The Times Trade Supplement* draws attention to the great possibilities of the British Empire in growing tobacco. He comments on the anomaly of an Empire possessing millions of acres of land suitable for tobacco cultivation not being able to supply anything approaching its own needs. An enormous increase in the consumption of tobacco in this country has taken place

in recent years, our imports having risen from 162,000,000 lb. in 1913 to 227,000,000 lb. in 1921.

The United States is the most important exporter of tobacco and exports all forms, particularly cigarette and pipe tobaccos, the American cigar requiring a particular taste which does not prevail to any extent outside that continent. Macedonia and the Crimea are next in importance for cigarette tobacco. What is known generally as Turkish tobacco comes from Macedonia, large quantities going to Egypt to be made into cigarettes there. The Crimea produces very important tobaccos used in the Russian cigarette blends which have grown in popularity very greatly in the last few years.

The countries producing cigar tobacco and cigars are Cuba (Havanas), the Philippines (Manilas), Mexico, Brazil, Java, Borneo, and Sumatra. From the last-named country come the finest leaves for cigar wrappers, Sumatra having almost a monopoly for the export of the first grade of this important commodity.

Tobacco growing in the British Isles has been spasmodic and is, perhaps, not likely to have any very conspicuous success. One expert explains it on the ground that to grow tobacco successfully you must grow it quickly, and that if it is left in the ground (as our temperate summers cause it to be) it becomes earthy, tobacco being notoriously sensitive to its surroundings, a fact which is, of course, utilised by scientific growers in obtaining a required aroma. Australia grows and uses a considerable quantity of tobacco, but is not an exporter to any appreciable extent. Canada has an important cigar and pipe tobacco industry, but has not yet been successful in supplying precisely the requirements of this country, although a certain quantity is now being sent here and Canadian growers are evincing a very great interest in the requirements of this market and endeavouring to meet them. Indian and Burmese cigars and cheroots will always command a certain definite market, and some Indian tobaccos have latterly been used increasingly for blending. British North Borneo, too, has come prominently into the market of this country recently; but for the future it is likely that Africa will provide the most suitable field of development. The pipe tobaccos of the Union of South Africa are already well-known and established here Rhodesia has produced tobaccos of admirable quality, and though the industry is extremely undeveloped there the possibilities are without question great. Of East and West Africa there are endless enthusiastic reports by settlers and other observers, but few reduced to the basis of facts and figures. The general botanical information, however, in regard to both sides of the continent would lead one to suppose that a cigar tobacco of some value can be grown, especially in the west; indeed, the writer has been told by experts in this country that samples of leaf have arrived of a quality which, with care and development, may one day rival the wonderful Sumatra wrapper leaf. But Nyasaland, more than anywhere else in the Empire, offers possibilities as the future tobacco field of the British world for cigarette and pipe tobacco. The qualities of its product are admirable, great enterprise has been shown by British concerns in that part of the world, and a considerable development of scientific production has resulted.

JELUTONG.*

The Jelutong Tree—indigenous to Sarawak—is found in old jungle in swamps at the foot of hills; it has not yet been cultivated, and there are still large districts where the trees are in sufficient quantities to provide employment for numbers more than are now engaged in this industry

The work would appear to be particularly suited to the native population who are not possessed of much capital, a worker's outfit being of very little expense to him; however, with the usual improvidence of the Malay, these people generally require advances of cash from a Chinese trader before they will work Jelutong.

Dyaks move from their homes for long distances to districts where these trees grow, the people of Batang Lupar and Rejang travelling to the Balingean, Bintulu, and Baram districts.

The following brief description will give an idea of the method of working this produce:—

A journey is made by boat to a likely district on the banks of a river and search is made in the jungle at the chosen spot; if a clump of trees is found near at hand a path is cleared to the banks; the felled trees being laid end to end, form a path through the swamp. From this clump search is made to the next clump, which is again joined up by a path of felled trees The system continues until from 250 to 350 trees have been discovered and joined up. This "working" is sufficient for one man and is known as a "Jelutong path." The owner registers his path at the nearest Government station and is granted a permit, when it becomes his property so long as he works it. The tapping of jelutong trees is supervised by Government which provides inspectors to see that tapping is carried out according to regulations and also that all owners and workers are registered. Previous to this control the native preferred to tap the tree to death to secure a quick profit to himself with no thought to

* Extracted from "Notes on Sarawak Trade," published by the Committee for Agricultural and Forest Exhibits, Malay-Borneo Exhibition

the future; in fact, he even felled the trees so as to extract as much latex as possible in a short time.

Having registered his path the owner employs tappers, if he has discovered a large supply of trees, but 250 to 350 trees will provide work for one man; 40 to 50 trees can be tapped in one day, and the tapper passes from section to section until the whole "path" has been tapped; by this system a tree is tapped once in 7 days. The gouge tapping knife is used and the tree is tapped on the herring-bone system. When the tapping is out of a man's reach the gouge is mounted on to a stick.

Having tapped his 40 to 50 trees, starting at 7 o'clock in the morning, at 11 o'clock he starts collecting; for which purpose he uses an ordinary four gallon kerosine oil tin slung on his back. The latex after tapping runs into bamboo "cups," but if these are not conveniently available cloth bags are used. In the place of the usual zinc spout a jungle leaf is used, preferably the leaf of the rattan if near at hand. Sometimes cloth bags are used, both as cups, and to replace the kerosine oil tin.

If the "cups" contain more latex than can be carried in a kerosine oil tin the sides are built up with cloth, with sticks at the corners to make it rigid, thus giving additional height to the tin.

The coagulating sheds are usually built at a convenient position on the river bank, where the worker sleeps and lives.

Here the gathered latex is poured into a tub and coagulated with a mixture of 1 tahil gypsum to 1 pint of kerosene oil, this quantity being sufficient coagulant for one tin of latex.

The coagulant and latex are stirred together for ten minutes and then left till the next morning, when the coagulated jelutong is made up into cylindrical or square blocks (beluku), which are stored in fences on the river bank by the owner's living quarters.

From time to time his stock is brought to the nearest bazaar for sale or delivery to the merchant from whom he has received advances.

Shipment is made to Kuching in steamers and schooners. On arrival it is usual for the shipment to be tendered for; the prices tendered form the local market rate until the next shipment arrives.

There is 60 to 70 per cent. of moisture in raw jelutong at the time of shipment.

European firms using raw jelutong locally have found it more economical to buy supplies through Chinese agents rather than to make advances to the jelutong workers direct.

Recently a new method of coagulating raw jelutong has been introduced, the treatment taking place in the jungle and delivery being made in the form of bricks.

Considerable quantities of raw jelutong are being refined locally by Chinese traders. The process is as follows:—

The coarser impurities are removed, and the cleaned jelutong is boiled; during this boiling an "acid" is mixed to aid the refinement; although this "acid" is used, it is very doubtful if any process, further than extracting impurities, is necessary, the quality of refined jelutong depending on selection of first quality raw material which is quite fresh.

The "acid" mixture is supplied to the Chinese by Malays from Singapore and the F. M. S., who, relying on the credulity of the Chinese, inform them that they possess the secret of a mixture which will ensure the best quality of refined jelutong.

These men are paid comparatively large salaries or retaining fees on condition that they will not supply their mixture to others, but although the greatest secrecy is observed as to the contents of this mixture, there appears to be only one thing definitely known, and that is that the acid used in the secret mixture dissolves a quantity of the rubber content of raw jelutong and causes the refined article to be of inferior quality to that manufactured without its use

GENERAL NOTE.

Food Paste Industry in Algeria.—Algeria has peculiar advantages for the development of the food paste industry, writes the United States Consul at Algiers Besides an abundant supply of cheap labour, the country raises a variety of hard wheat particularly suitable for making good macaroni. Some fifty factories make daily about 40 metric tons, employing mostly women and girls on machines and in packing. Since 1912, when the exportation of this product amounted to only 2,659 metric tons, the industry and export trade have both increased, except during 1918, when war conditions caused a slight decline. In 1919, exports amounted to 8,773 metric tons, and in 1920 to 3,129 metric tons, of which France received 2,796 tons. It is thought that, including exports and local consumption, the value of food pastes manufactured in Algeria during 1920 amounted to about 10,000,000 francs.

Corrections.—The following corrections should be made in the paper on "Irrigation Enterprise in India," by Mr. F. W. Woods, C.I.E., which appeared in the *Journal* of September 8th, 1922:—On page 721, column 2, line 20, for 187.1 read 185.7; and in line 23 of the same column for 186.5 read 185.0.

On page 722, at the end of section 41, insert the following:—"The winter-crop area, of 900,000 acres, can be irrigated by a continuous flow not exceeding 5,500 cusecs, which requires a water depth of 6 feet, or a water surface level of 181.0 in canal at head. This level is well below the lowest recorded water surface level of the river at the site under consideration."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

EXAMINATIONS.

The results of the Stage I. (Elementary) Examinations, which were held from May 22nd to June 1st, were sent to the centres concerned on August 29th. Those of the Advanced and Intermediate Stages were issued on the 2nd and 17th of August, respectively.

The total number of papers worked in all three stages at the May-June Examinations was 35,802, an increase of 219 on the corresponding examination of 1921.

In the Advanced Stage 6,052 papers were worked: 769 First Class certificates were awarded; the Second Class certificates numbered 3,247, while 2,036 papers were classed as failures.

In the Intermediate Stage the number of papers worked was 14,313, made up of 2,751 First Class and 7,378 Second Class certificates, and 4,184 failures.

Of the 15,437 candidates in the Elementary Stage, 10,504 passed and 4,933 failed.

In the two examinations held this year, the total number of papers worked in all three Stages was 56,775, as against 51,267 in 1921; an increase of 5,508. In the Advanced Stage, the number of papers worked was 8,423. In 1921, the number was 8,125. In the Intermediate and Elementary Stages the numbers were 20,216 and 28,136 respectively, as compared with 19,093 and 24,049 in 1921.

Altogether, 38,925 certificates have been awarded. These are now being prepared and will be issued to the various Centres as soon as ready.

The printed results of the Examinations are now in the press. It is hoped to issue those of the April series quite shortly, while the May results, with the list of winners of medals in the various subjects, will be sent out later in the year.

Two examinations will, as usual, be held in 1923. The first will begin on March 16th and finish on March 28th, the second will be held from May 7th to 17th. The time table has already been circulated to the Centres.

The 1923 Syllabus will be published in a few days, and, with the usual posters, will be forwarded to all Centres without delay.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROCESSES OF ENGRAVING AND ETCHING.

By ARTHUR M. HIND, O.B.E., M.A.

Slade Professor of Fine Art in the University of Oxford.

LECTURE I.—*Delivered November 28th*, 1921.

INTRODUCTION AND WOODCUT.

I am not treating the subject of the Processes of Engraving and Etching as a practising engraver, but from the stand-point of the historian and critic. I am chiefly concerned with the technical character of the various processes in the discrimination of their several characteristics and limitations, and peculiar fitness for certain kinds of work.

I would begin by emphasising the three main classes of prints:—

I. RELIEF PRINTS.

II. INTAGLIO PRINTS.

III. SURFACE PRINTS.

divided according to whether the black line of the design (i.e., the part inked for printing) on the original block, plate or stone, is

I. In relief.

II. In intaglio (i.e., cut into the surface).

III. On the surface (i.e., on a level with the rest of the work).

These three divisions correspond roughly with

I. Woodcut and wood-engraving.

II. Engraving and etching on metal.

III. Lithography (surface printing from stone).

My present course of lectures will deal with I. and II. only, and even in these divisions will omit various processes which would come under II. (such as mezzotint, aquatint, and other tone processes), being limited to woodcut and wood-engraving (the first lecture), line-engraving (the second lecture), etching (the third lecture).

The first slide I am showing is one of the original wood-blocks by ALBRECHT DÜRER, preserved in the British Museum, from the series of the *Little Woodcut Passion.* It shows very clearly that with an ordinary woodcut the part which is cut away is merely the negative portion of the design; the surface of the block is inked in the printing, so that it is the lines and spaces left by the cutter in relief that are the black or positive parts of the design. The wood used is either the plank of a soft tree, such as apple, pear, sycamore, or beech, or a section of box-wood. For work on the plank, which was usual until the 18th century, a knife was used, so that woodcut is the correct term for most earlier work; for work on the harder box-wood, which may have been introduced by Papillon, though perhaps only in the plank, the graver or burin is the tool (or other tools similarly pressed before the hand, *e.g.*, tint-tools, scorpers, and gouges). For illustration of tools and methods of work, I am showing on the screen Jost Amman's *Woodcutter* (from the "Panoplia Omnium Artium," 1568), a plate showing the *Use of the Graver* from the "Excellency of the Pen and Pencil" (1688), and Whistler's dry-point of the *Wood-engraver Paul Riault* at work (1860). The press used for printing woodcuts is practically the same as that used for type, so that a woodcut is in its very constitution perfectly fitted for printing in conjunction with type, and on that account the most suitable form of engraving for book illustration. Line engraving and etching, and any intaglio engraving, require a different type of press, so that an illustration would always have to be inserted, or, if on the page with the type, would require a second printing. The press is illustrated on the screen in another woodcut from Jost Amman's "*Panoplia Omnium Artium,*" and in an anonymous woodcut of the Dürer school which occurs on the title-page of a Herodotus printed at Paris in 1528.

I have spoken of the cutting of the ordinary *black line* woodcut as being the removal of the negative parts of the design. Another example shown, a *Standard-bearer* by Urs. Graf, illustrates another style of woodcut, the *white-line* woodcut, in which the part cut away gives the positive of the design as white line on black. It is obvious that this style offers a greater opportunity to the artist who cuts his own design on the block than the style in which the cutting is a negative labour, which might more excusably be left to a subordinate craftsman.

The earliest prints from woodblocks which can be dated with certainty are Japanese, of 764 A.D., but it is probable that the art was known earlier in China. In Europe—and my lectures are limited to European work—woodblocks were used during the middle-ages for impressing patterns on textiles, the pattern or block cutters being called the *Formschneider.* Paper only came into common use in Europe at the end of the 14th century, and it is about that time that the earliest European prints on paper from woodblocks can be dated. During the fifteenth century woodcut was largely used for the popular picture of saints and other scriptural subjects disseminated by the monasteries, and for playing cards, which were introduced in Germany at the end of the 14th century, though no packs can be dated much before 1450. The earliest style of work, the simplest system of design cut in broad lines, is illustrated in an *Agony in the Garden* (Paris, Bibleothèque Nationale), by an unknown (Burgundian ?) master, generally called the *Maître aux Boucles,* while work of the last half of the 15th century, coloured by hand, is shown in a *Portrait of the Sultan* (British Museum). The "Block Books" (*i.e.*, books in which the page, picture as well as type, is entirely cut on the wood) have generally been regarded as the forerunners of printing from moveable type, but none of them can be dated with any certainty before 1460, *i.e.*, at least a decade later than the introduction of type-printing. But even a single leaf woodcut with text cut on the same block possesses all the essential elements of the block-book, and of these some certainly date before the earliest printed books, so that in principle at least the block-book is the forerunner. I am illustrating this class of work by a page from the *Apocalypse.*

A large woodcut, *View of Florence,* in Berlin (of about 1490), illustrates a common early use of the process for topography and maps, uses for which it was superseded

at successive periods by line-engraving and lithography. Large cuts of the sort (and another illustrated is Domenico delle Greche's *Destruction of Pharaoh's Host*, after Titian), are printed from several blocks, the various impressions being joined together.

In Albrecht Dürer (1471-1528) woodcut reaches its highest development. We speak of Dürer as wood-cutter, but, in all probability, Dürer was only the designer of his woodcuts, and this may have been the case with the majority of early so-called wood-cutters. But with black line woodcut I do not regard it as so essential that the artist should do his own cutting, as long as he designs with a clear view of the style most fitted for the process. In some of his more detailed designing, *e.g.*, the *Holy Trinity*, of 1511, Dürer may have almost touched the limits of the true capability of the process, and in many of his later blocks, *e.g.*, the *Last Supper*, of 1523, he reverts to the more open style of design with less cross-hatching which characterises his early work. I am illustrating his early phase in which the Gothic elements are still strongly in evidence, by the *Agony in the Garden*, and the *Riders on the Four Horses*, from the Apocalypse, the latter a wonderful inspiration, and as fitting in its conventions of style as anything he ever did. Of later work the *Taking of Christ* (1510), from the large wood-cut Passion, is a splendid example, with forms and composition already influenced by the Venetians, an influence which added mellowness and dignity to the cruder Gothic of his origin. Of Dürer's contemporaries and immediate followers, I am showing you one example of Altdorfer, who did a considerable number of small woodcuts of peculiar fascination (*the Holy Family at the Fountain*), and another of *Lucas van Leyden*, the most interesting of the engravers of the Netherlands of the early sixteenth century. But second only in interest to Dürer as a designer for woodcut is Hans Holbein, the younger (1497-1543). Nothing more perfect in their own simple conventions has ever been done than his two series of small cuts, the *Illustrations to the Old Testament* and the *Dance of Death*, both of which were first published in small quartos at Lyons, in 1538. Holbein's cutter, Hans Lützelburger, is among the few craftsmen of the period whose fame has remained alongside that of the designer.

The two succeeding centuries were comparatively barren in woodcut, but a few names stand out for mention: Jan Lievens, Rembrandt's contemporary, for some excellent portraits, and a study of trees; Dirk de Bray, for a few attractive blocks (*e.g.*, a series of the *Months* illustrated in Dutch Views), and a greater mass of hack work, and Christoffel Jegher, for some powerful cuts after Rubens. In the eighteenth century Papillon cannot be forgotten, but rather as a craftsman than an artist of distinction. He produced countless small book illustrations (head-and-tail pieces and the like), and wrote a valuable book on the art of wood-engraving.

Book-illustration is undoubtedly the fittest sphere for woodcut and wood-engraving. Apart from the method of printing being the same for woodcut and type, a practical convenience of great value, the strength of a woodcut impression seems to be a better artistic balance to type than the more forcible prints obtained from an intaglio plate.

The Italian publishers of the late fifteenth and early sixteenth century fully realised this, and no more beautiful illustrated books have ever appeared than those of Venice at this period. The most attractive of all is, perhaps, the *Hyperotomachia Poliphili* (printed by Aldus, Venice, 1499), from which I am showing an illustration on the screen. Another interesting volume is the Mallermi Bible, printed at Venice in 1493, with little woodcuts, in which Holbein certainly found inspiration. A block, illustrated in another slide, from Pulci's *Morgante Maggiore*, Florence, 1500, shows a use of the white line, which is characteristic of Florentine work of this date. The elements of the white line are found earlier in the metal-cuts in the *criblée* manner (illustrated in a *Crucifixion* in the British Museum), and in the dotted backgrounds of a series of French woodcut illustrations of the earlier part of the sixteenth century (*e.g.*, *Books of Hours*, Paris, 1510). But it remained for Thomas Bewick, at the end of the eighteenth and in the early nineteenth century to develop the white line to its fullest capabilities. And comparison of Bewick's work with Papillon's is generally much in favour of the former: partly, perhaps, due to the added clearness and delicacy in engraving achieved by his use of boxwood cut across the grain. His work may not rise to great artistic heights, but in its limited and somewhat pedestrian sphere, *e.g.*, in his book of

Birds, it is very perfectly adapted to its purpose.

Bewick's more famous contemporary, William Blake, did little woodcut, but one series of little cuts illustrating Thornton's *Pastorals* (Virgil), 1820, are among the most perfect achievements in the whole history of the art. A considerable part of Blake's own illustrated books are printed from relief blocks in the manner of woodcut, but they are on metal, and for the most part etched in relief, not cut or engraved. Another charming example of the period is seen in the small illustrations to Rogers' *Poems*, 1810, cut by Luke Clennell after Stothard.

Very different in style from these are the wood engravings of the illustrators of the "Sixties," exemplified on the screen in a design by Pinwell for "She Stoops to Conquer," which was engraved by Dalziel. The manner of these illustrators, of whom Millais, Rossetti and Sandys were the leading figures, was essentially that of pen draughtsmen without very definite thought of style suited to the character of wood. But the wood engravers of that time had a skill of interpretation in the rendering of the most delicate line and the varieties of texture, that was fully able to cope with the difficult task set them. Nevertheless, in spite of the charm of much of the work done, I doubt the propriety of this style of work on wood. Modern photographic processes have largely ousted its use, and most present-day wood engravers are probably right in their return to the use of a simpler method, continuing the traditions of the sixteenth century, or such later Masters as William Blake. The return to Venice and her ideals, though treated in a thoroughly individual spirit, is illustrated in the woodcuts of the Kelmscott press, in which Morris and Burne-Jones were the chief designers, and Hooper the best known engraver, while an even closer reflection of Venice is seen in the beautiful woodcuts of Charles Ricketts in the Vale Press. Easily first among the private presses still issuing books with woodcuts in England is Lucien Pissarro's "Eragny" Press, which started on the basis of the Vale fount, and has produced many books of great beauty.

Among the younger generation of artists there are a considerable number doing excellent woodcuts (*e.g.*, Eric Gill, Noel Rooke, Mrs. Gwendolen Raverat, Philip Hagreen, John and Paul Nash, Robert Gibbings) and a Society of Wood Engravers has recently been formed. With such material at their hand, it is to be regretted that publishers do not have more frequent recourse to this most perfect form of illustration. Process reproduction may give more freedom to the designer, but this freedom from convention generally leads to a license, by which the works produced bear no artistic relation to the page of type, and to the consequent degradation of the art of book illustration.

LECTURE II.—*Delivered December 5th*, 1921.

LINE ENGRAVING.

My first lecture dealt with prints from blocks cut in relief; my present and succeeding lectures deal with impressions taken from intaglio plates. In line-engraving, the line which prints black is a furrow in the plate, cut, or engraved by the graver or burin. The form and use of the graver are illustrated on the screen in a plate from "The Excellency of the Pen and Pencil," 1688. The printing requires a different press from woodcut or type, called the copper-plate press, in which the bed passes between double rollers to give the much greater pressure required. The lines of the plate are first filled with printer's ink, and the surface cleaned (so that the parts between the lines shall remain brilliant and white). The plate is then laid on the bed of the press, and, in conjunction with damped paper, placed on it and protected by blankets, is pulled through the press. The damp paper is pressed into the lines sufficiently to drag out the ink, which thus stands out on the impression in a relief corresponding to the depth of the engraved furrow. It is this relief in the line (felt by the finger passed over an impression) which gives the distinctive quality to the line of an engraving or etching, which the flat line obtained by the pen can only imitate superficially. It imparts a strength of tone quite impossible in pen work, and in the regular conventions of line-engraving an unequalled brilliance of texture as well.

In contrast with black line woodcut, line-engraving is a positive as against a negative process, as the line cut by the engraver is the positive line of the design, not the white interstices. So that, from this point of view, Ruskin was right in his premises when he claimed for line engraving that

"its line can only have its full value under the vivid first force of imagination . . . while a woodcut may be laboriously finished, an engraving on metal must be comparatively incomplete." But his conclusions are, I think, much open to question. Elaboration is justified in either art as long as the special value and quality of the line is preserved, and in its quality I think there is little doubt that line engraving can bear a more delicate elaboration than work on wood, whose style is best preserved by a breadth of treatment and simplicity of line. This is a matter which may best be considered in relation to particular engravings illustrated on the screen.

The first half dozen examples I am showing from various periods to illustrate certain technical characteristics. First, the *Peasants going to Market*, by Martin Schongauer (the most interesting of the German engravers of the 15th century before Dürer), shows very clearly the regular combination of line and short flicks which form the basis of the line-engraver's method. An example by Jan Muller, one of the most skilful of Flemish engravers of the earlier 17th century, a *Portrait of Isabella Clara Eugenia*, after Rubens, is given in two states, the first showing the engraver's* method of sketching out the main outlines with the dry-point (or by a light use of the graver); the second the finished plate, the outlines being clearly engraved and the composition completed by a very delicate and regular system of parallel lines, curves, cross hatchings and flicks. Then the famous *Adam and Eve* (1504), by Albert Dürer, the greatest of original line-engravers, also in two states, showing how the artist, after outlining the composition, completed the plate piece by piece, rather than advancing by stages throughout the whole subject as an etcher would more naturally do.

The portrait of *William Sanderson* (1658), by William Faithorne, the *Portrait of Himself* (1749), by Hogarth (issued later completely transformed as the *Bruiser*, in reply to Churchill's satirical attacks), and the *Portrait of the Earl of Arundel*, after Van Dyck, by William Sharp, are further examples showing how a plate can be developed or transformed in its various stages or states. Sharp's portrait is a good instance of the regular eighteenth century method of beginning a line-engraving with a preliminary etching.

*An Instrument used more by Etchers, and described in my next Lecture.

I will next give a survey of the historical development of the art in relation to original and reproductive work, with some particular reference to portrait and book illustration, ending with some remarks on its use and possibilities at the present day.

In its origins line-engraving was a development of the goldsmith's craft; for engraving, apart from printing, is one of the oldest forms of decoration on metal. A special class of goldsmith's work chiefly practised at Florence and Bologna in the latter half of the 15th century, that of *Niello*, in which the engraved lines on small silver (or gold) plates were filled with a black substance (niello) to show up the design, comes very near in style to line-engraving in our sense. Vasari goes so far as to say that line-engraving was a development from niello, Maso Finiguerra, the Florentine goldsmith (1426-1464), finding in the course of his work that an impression on paper could be taken, and be of value in itself. It is doubtful whether any of the Florentine nielli are as early as certain of the most primitive Italian engravings, and in any case the earliest German engravings are probably a generation earlier than Finiguerra's first work, so that the tradition that Finiguerra was the inventor of engraving falls to the ground. But even if engraving did not actually find its origin in niello work, the two processes undoubtedly closely reacted on each other's development. I am illustrating this point, and the identification of certain early Florentine engravings with Finiguerra's work (a case argued in detail by Sir Sidney Colvin in his "Florentine Picture Chronicle," and in the British Museum official catalogue of Early Italian Engravings) (1) by the comparison of a Florentine niello of a *Cupid* and a similar drawing in Florence, which had been traditionally ascribed to Finiguerra; (2) by the engraving of *Theseus and the Cretan Labyrinth*, and the drawing after the same subject from the *Florentine Picture Chronicle* in the British Museum; (3) by the engraving of *Mercury* from the early Florentine series of Planets. The *Mercury* is particularly interesting in the history of the craft, as it shows a goldsmith's shop open to the streets of Florence, in which the goldsmith is engaged engraving a large copper plate.

One of the most beautiful of the Florentine engravings in the same manner as those already cited and attributed to Finiguerra is the *Bacchus and Ariadne*, only known complete in the impression of the British Museum. If not designed by him, it is certainly inspired by Boticelli. Another slide shows examples from two series of the *Sibyls*, (*a*) in the same style as the Finiguerra engravings (*i.e.*, with a strong outline and close but rather irregular shading) called the "Fine Manner" in Florentine engraving; (*b*) in a broader style with regular parallel lines of shading, laid fairly openly and with a light return stroke at a small angle, called the "Broad Manner." The former is the development of the goldsmith's manner, the latter a more definite imitation of a painter's manner of drawing in pen and ink. The "Broad Manner" of Florentine work is very similar in technical quality to the engravings of Andrea Mantegna, the most famous of the North Italian engravers of the fifteenth century, whose prints I am illustrating in his *Virgin and Child* and the *Christ between St. Andrew and St. Longinus*. His work on the copper is full of subtle quality, and owing to the lightness of the return stroke between his parallel lines of shading, his plates must have soon lost their fresh bloom, so that while good impressions are very rare, later impressions which only preserve the strength of the design in the principal lines are by no means uncommon.

Early German work I have already illustrated in Martin Schongauer. I am giving another example of the predecessors of Dürer in Israhel van Meckenem's *Portrait of Himself and his Wife*. Van Meckenem was a goldsmith, not a painter like Schongauer, and less of an artist, but his work is, nevertheless, full of human interest and humour.

Albrecht Dürer, the son of a goldsmith, fills the central position in the art of original line-engraving, as he did in woodcut, and I am showing a considerable number of his works on the screen. The *Prodigal Son*, one of the most beautiful examples of his earlier work, before 1500, with its attractive Gothic farm buildings, *Peter and John healing the Cripple*, one of the sixteen subjects of the copper-plate Passion (1507-13), already showing in its treatment of composition the influence of Venetian art; the *Melancholia*, one of the most wonderful and imaginative of all his works, packed full of detail, but none the less concentrated on that account; the *Virgin and Child by the City Wall* (1514), the *St. Anthony before the Town* (1519), these two with architecture so characteristic of Nuremberg, and the *St. Christopher* (1521). In the perfect conviction with which every line is laid on the plate, in a convention of extreme beauty and fitness in his treatment of the medium and in the imaginative force of his inventions, Dürer has never been surpassed by any other line-engraver.

Two of his contemporaries came near him in technical excellence, each showing qualities of his own hardly inferior, i.e., Lucas van Leyden (1494-1533) in the Netherlands (illustrated by the *Milkmaid*, a charming study from nature, a forerunner of the Dutch genre of the succeeding century) and Marcantonio (about 1480-about 1530) in Italy. There is less of intellectual force in either of these than in Dürer, but a certain gentleness of sentiment and delicacy of craftsmanship in Lucas van Leyden gives his work a peculiar charm, and for classic beauty of form Marcantonio is pre-eminent. One factor in Marcantonio's work that calls for comment is the reproductive side. A great part of his work was based on other masters, on Raphael in particular, but as far as we know the originals, it is never close reproduction, but a free and personal interpretation. We speak of most of the fifteenth century engraving as original, but in many cases it may only be that we are ignorant of the masters who gave the inspiration. Robetta (1462 to about 1522) is one of the forerunners of Marcantonio in Italy in whom we can trace the same individual use of other artist's designs, e.g., in his *Adoration of the Magi*, based on Filippino Lippi's picture in the Uffizi, but provided by the engraver with new elements in the group of angels above, and in the landscape with its suggestions from Dürer. It is interesting to trace reproductive art in the school of Rubens, who, like Raphael, had various engravers working in his studio. His case was one of the first systematic attempts at the sort of publicity that photographic reproduction can give to-day. Van Dyck also carried out a large scheme of reproduction by engraving, in his *Iconography*, a series of portraits of famous men, based on his paintings and drawings. I am illustrating his method by showing three stages in the making

of one of these portrait engravings, that of *Count Frockas de Feria*. First, the drawing in black chalk (at Chatsworth), then an oil grisaille on panel (in the Duke of Buccleuch's collection), and finally the engraving by Paul Pontius, which was probably directly based on the grisaille. In other cases there also exists Van Dyck's larger oil painting on which he based his further work in view of the engraved series.

I am illustrating reproductive engraving in the succeeding century by N. H. Tardieu's print of Watteau's *Embarquement pour Cythère*, and William Woollett's *Niobe and her Children* after Claude. Engraving has never reached a more remarkable sublety and variety of tone than in the best work of the Watteau engravers, a variety that gains much from the admixture of delicate etching. In Woollett the preliminary etching shows in its worm line almost too rigid a system, with a resultant deadness of effect. The same criticism may be applied to the majority of the large reproductive line-engravers of the earlier nineteenth century, e.g., Raphael Morghen (illustrated by his *Madonna del Granduca*, after Raphael), though considerably less to the school of engravers who worked after Turner. There is far more etching than engraving on the plates of most of the Turner engravers, but the work was always finished off with the graver, and the general convention of their style justifies their being considered under the category of line engraving rather than etching. The use of steel plates in place of copper, introduced about 1820, but soon superseded by steel facing of the copper by electrolysis, made it possible for much larger editions to be printed from the plates, a matter of considerable value in the use of the art in book illustrations.

Occasional experiments of illustrated books with line engravings are found in the fifteenth century (e.g., Pendino's *Dante*, Florence, 1481), but the necessity for two printings, apart from the artistic instinct that woodcut was more suited from its style, probably prevented its frequent use. But in spite of this difficulty, it became the predominant medium for book illustration in the seventeenth and eighteenth centuries, when the tendency may have been to slight woodcut as an inferior art. This may have arisen from the fact that the wood cutters in the earlier periods belonged to the same guilds as the carpenters, probably something less in the scale than the goldsmiths and line engravers. And a side light on the status of the line engraver is provided by an edict of Louis XIV., obtained by the efforts of Nanteuil, raising engraving to the position of one of the Liberal Arts.

The most attractive school of line engraving in book illustrations is that of France in the latter part of the eighteenth century, and I am showing three examples, one by Gravelot after Pasquier from *L'Ecole des Pères* (1765), a decorative piece by Delaunay after Eisen, from *Les Baisers*, and a miniature portrait of *Lafontaine* by Ficquet, from an edition of the Contes (1762). No more accomplished work in miniature portrait engraving has ever been done than by Etienne Ficquet.

In my last subject divisions I am showing a few examples of portrait engravings taken from various periods: the famous *Erasmus* by Dürer, a wonderful example of decorative portrait engraving; the *Cardinal Bentivoglie*, after Van Dyck, by Jean Morin, among the earliest engravers to combine the engraved with the etched line; the *Habert de Montmor* by Claude Mellan, distinguished by an individual style in which variety is added to the effect obtained by open parallel lines of shading, by means of a constant use of the swelling line; the *Christina of Sweden* by Nanteuil, the greatest of the French portrait engravers; the *Guilleume de Brisaccer* by Masson, an example of the most extraordinary brilliance, but metallic in effect; the *Lady Paston* by Faithorne, the great English contemporary and no mean rival of Nanteuil, and the *Bossuet* after Rigaud by Pierre Isbert Drevet, of the beginning of the eighteenth century, when the attempt to render variety of texture had almost passed the limits of what line engraving can bear and still retain its strength.

Comparatively little original work has been done in line engraving during the nineteenth century, and William Blake's *Book of Job* (1825) is pre-eminent in its isolation, fit to take its place as a work of the highest imagination, done in the best conventions of the craft, beside the work of Dürer.

At the present time, the photomechanical processes have largely ousted engraving from the field of reproduction, and the medium is used little except for heraldic work. In many

respects these more exact reproductions may have helped towards a wider knowledge of the history of painting, but with all its exactness there are occasions when the artist's vision is able to render in monochrome the values of a painter's colours with much truer effect than the camera. And beyond this, the quality and texture of his reproduction is generally immeasurably more interesting than the best of the photographic processes. The few reproductive engravers that remain, such as Mr. Macbeth-Raeburn, work for the most part in mezzotint, and they have received little enough encouragement. If line-engraving is less likely to be used for reproduction work in future, I see no valid reason why certain modern artists should not try to recover the use of the graver for their original design, *e.g.*, etchers like Gerald Brockhurst and F. L. Griggs, with their devotion to precision of line in etching. One of the few recent etchers who have returned to the graver is William Strang (illustrated on the screen in a *Portrait of Frederick Goulding*, the copper-plate printer), but his work with the graver practically corresponds in its appearance to dry-point. He had a graver hooked back at the point, after a device of his own, and pulled it through the plate as in drawing, the advantage that he claimed over dry-point being greater strength and lasting power in the line.

For heraldic work line-engraving is not likely to be superseded, though woodcut is always a good second in original book-plate design. Mr. J. F. Baddeley and the late Mr. G. W. Eve and Charles Sherborne are notable names in this field. In this relation I would recur in my last illustration on the screen to the wonderful *Coat-of-Arms with the Cock* by Albrecht Dürer, one of the marvels of engraved heraldic design. In face of this work, so perfectly convincing in its fitting use of the medium, Ruskin's dogma that an "engraving on metal must be comparatively incomplete" falls to the ground, for nothing of the real value of the line has been lost. With its qualities, so distinctive in the dignified conventions proper to its style, and in the peculiar force of the clear cut line printed from an intaglio plate, I feel convinced that the day of line-engraving in the broader fields of competition, whether for original or reproductive work, is not past.

Lecture III.—*Delivered December 12th, 1921.*

ETCHING.

My present lecture, like my last, deals with prints taken from intaglio plates, but in the present case the furrow in the plate is bitten by acid, not cut with the graver. The popular confusion of etching with pen-drawing is still too common, etching being, of course, by derivation eating, *i.e.*, biting with the acid. The one justification for the confusion is a superficial similarity of the etcher's style, which shows the same freedom as the draughtsman's, to pen drawing. But I have already emphasised the qualities of relief of the line printed from an intaglio plate, from which pen drawing differs so essentially in quality.

To help in the description of the process I am putting on the screen the plate showing etchers at work from the 1758 edition of Bosse's *Traicté des manières de graver*. On one side an assistant is seen covering the plate with the etching ground (a composition of various waxes, gums and resins), bringing a little silk bag of the substance in contact with the plate, which is being heated on a stove; the melted wax is then laid evenly over the surface of the plate by repeated taps with the dabber (a small pad covered with silk or kid). In the centre this grounded plate is seen suspended from the ceiling, and another figure is passing lighted tapers beneath it to blacken the ground. Then at a table on the left the artist is seated drawing through the ground with the etching needle (a steel point of varying thickness, generally set in a handle), opening up the surface of the copper, which appears bright against the blackened ground, where the lines are required. In the background two other assistants are represented biting the plate in a bath of acid, the edges and back of the plate having first been protected by varnish. This process of biting may be repeated if necessary for parts of the work which require deeper lines, the light portions being protected by "stopping-out" varnish.

The other process which inevitably enters into any discussion of etching, as it is so used in conjunction with etching, though in its principle it is more allied to engraving, is *dry-point*. Here the furrow is obtained by means of a strong steel point, somewhat of the shape of a pencil, drawn through the surface in the same way as the draughtsman

uses a pencil. The resultant furrow is not so deep as that obtained by the graver, and the curl of metal which the dry-point throws out at the side is generally left, and not scraped away as in line-engraving. For the aim of the line engraver is clearness of line, and this curl of metal would hold ink, which adds a deep cloudy effect at the edge of the line called the burr, one of the characteristic qualities of dry-point. This burr is very delicate and comparatively few impressions (fifty or not much more) wear it away, so that late impressions of dry-points are mere ghosts of the rich earlier effect. On the other hand, the clear furrow of line-engraving or etching, particularly in plates with broad open line, will outlast many hundreds of impressions (on the copper—apart from the added life steel facing would give) without any rapid deteriorations, as long as care is used in the printing.

In the case of old master engravings and etchings there seems seldom to have been any artificial limit to editions. Plates went on being printed, in many cases after the death of their authors, very much at the mercy of the publishers or printsellers into whose hands they fell. If the plate were strongly engraved or etched it might be yielding tolerable impressions a century or more after its making. From the artistic standpoint alone there is no reason why any limit should be made, except the lasting power of the plate or block. Only the etcher who prints his own plates, a very advisable practice where anything depends on the variety of tone obtainable by leaving a vestige of ink on the surface, will come to the limit of his patience and may on that account prefer to make a smaller edition rather than leave the plate in other hands to print. But, in general, I think the ruling factor is the public, which thinks more of rarity than art, and the printsellers who correctly gauge the demand. One satisfactory feature is that destroyed plates are out of harm's way, but the future collector of, let us say, Muirhead Bone, will miss much of the connoisseur's delight in distinguishing the good from the poor impression.

The origin of etching may be traced back to the armourer's craft, in whose workshops the process of etching decoration on iron was certainly known at the beginning of the fifteenth century and probably at a much earlier period. Daniel Hopper, an armourer, who worked in Augsburg between 1493 and 1536, was probably printing etchings from iron plates as early as 1500 (*e.g.*, the *Portrait of Conrad von der Rosen*, shown on the screen), but there are no dated etchings before 1513, the year of Urs Graf's *Girl bathing her feet* (of which the only impression known is at Basle). Dürer made six essays in etching between 1515 and 1518, all of them on iron, to judge from the coarse quality of the line, one of which I am showing on the screen (the *Cannon*). Dry-point goes back somewhat earlier than etching, the interesting plates of the anonymous Master of the Hausbuch, of which Amsterdam has the best collection, belonging to the latter half of the fifteenth century. Whether scratched with the graver or dry-point matters less than the fact that the burr is left to give the effect characteristic of dry-point.

Dürer himself also produced three plates in the medium, the one I am giving on the screen, *St. Jerome in the Wilderness* (1512), showing an appreciation of the possibilities of the process which was not surpassed even by Rembrandt. I place in comparison with it a slide of Rembrandt's *St. Jerome by the Pollard Willow* (1648), done in etching with touches of dry-point, interesting to show their respective treatments of the same subject, in each of which the study of a willow from nature is of the greatest truth and significance of drawing. In spite of Dürer's occasional success in using both dry-point and etching, it is probable that in their freedom of style neither really responded to Dürer's feeling for the sterner conventions of lineal style, for which woodcut and line-engraving were the best means of expression.

After his three essays in dry-point, practically nothing was produced in the medium, except the work of Meldolla, in Italy, until the time of Rembrandt. The surface quality of Meldolla's plates, which often show cracks, is noteworthy, and has led to the surmise that he used a softer metal than copper, possibly pewter. But Mr. Strang who examined his prints with me some years ago was not prepared to accept this suggestion.

On the other hand, etching was used to a considerable extent during the sixteenth century, though it never came into its own until the succeeding century. The two examples illustrated are a charming figure subject called *St. Thais*, by Parmigiano,

and a little oblong landscape of 1546 by Hirschvogel, most attractive in its quaint conventions of curving strokes.

I am now putting before you a series of illustrations from various periods under the section of landscape, architecture, subject, and portrait, which may give a more vivid picture of the different characteristics of old and recent masters and their treatment of similar problems.

First, dealing with *Landscape,* the example by Jan van de Velde, a somewhat older contemporary of Rembrandt, a Dutch country scene in a storm of rain, *March,* from a series of the months, is done in a convention of drawing which still reminds one of the landscape of the elder Peter Brueghel and of Paul Bril. His work has a peculiar charm, the same flavour that one meets again in Wenzel Hollar, by no means alien to the style of modern landscape etching of the more imaginative style.

In Rembrandt (1606-1669) we find the most perfect conventions of drawing and etching, with an almost complete absence of mannerism. He was constantly making drawings from nature, but of some three hundred etchings only about thirty are of landscape. In some cases he certainly etched his landscape plates in the studio, *e.g.,* the *Cottage and Haybarn* of 1641, where elements that could not be seen in the same way from one place are combined in the subject (the Chateau of Kostverloren on the Amstel, and Amsterdam in the background). But two examples I am showing on the screen are probably etched on the plate direct from nature, *Six's Bridge* and the *Vista.* The old story that Rembrandt etched the former of these plates for a wager while a servant brought the mustard, which had been forgotten, from a neighbouring village, may at least contain this kernel of truth that the artist carried a grounded plate in his pocket when in the country. The simplicity and directness of the treatment certainly favours the assumption, and if Mr. Lugt (who has identified so many of Rembrandt's landscapes in his recent book, "With Rembrandt in Amsterdam") is correct in his identifications, most of his prints come in the reverse direction to the actual scene. Now the first state of the *Vista* was probably sketched from nature, and the second state completed in the studio with certain elaboration in the mass of trees, and the addition of the signature.

There is much interesting landscape etching in the seventeenth century that I would illustrate, had I the time, particularly Claude, though his work in etching has far less importance than his wonderful landscape drawings; but in many ways the best complement to Rembrandt in landscape etching only comes in the nineteenth century, and I will skip the intervening period. At the very beginning of the last century is the series of *Views of Paris,* by Thomas Girtin, done in the last year of his short life (1802). In their early states they are etched in line by Girtin himself, a tone being added afterwards by other engravers in aquatint. The *View on the Seine,* shown on the screen, is of spacious composition, and a very sensitive quality of line. Crome is illustrated in his etching of *Mousehold Heath,* in a later state in which the clouds somewhat overbalance the rest. Without colour the balance of sky and ground is often of the greatest difficulty. Nineteenth century masters have experimented more in this direction in etching than the earlier masters, but they have not got further than Rembrandt's *Three Trees* or *Long Landscape with Farm Buildings and a Church Tower.* Perhaps Rembrandt's instinct in avoiding too much sky for the most part in etching, was the right one.

Of Turner, I am showing an example of his etchings, from the "Liber Studiorum," the *Junction of the Severn and the Wye,* one of the most beautiful of his subjects, in the tradition of Claude. But he treated the etched line as the mere skeleton of his subject, covered afterwards in mezzotint by his own or another hand, to imitate his drawings in monochrome wash. But this skeleton shows drawing of a significance that can only be surpassed by such masters as Dürer and Rembrandt. Other nineteenth century landscape etchings illustrated on the screen are *Peckham Rye,* by Andrew Geddes, of interest in its revival of drypoint (which had been seldom used with effect since the time of Rembrandt), the *Lisière de Claribois,* by Théodore Rousseau, reminiscent of Ruysdael, but stronger than any of Ruysdael's etchings in its massing of trees, the *Kew Railway Extension,* by Seymour Haden, the magnificent *Ben Ledi,* by D. Y. Cameron, and James McBey's recent *Camel Patrol,* and more imaginative work in Mathys Maris's *Enchanted Castle,* and *Death of the Woodcutter,* by Alphonse Legros, an etcher who never had the full

recognition that the great beauty of his work deserves.

As examples of architecture, I am comparing the work of Reinier Zeeman (1623 to about 1663), in his *Porte St. Bernard, Paris*, with the *Morgue*, perhaps the finest of the etchings of Charles Meryon, himself a sailor in his youth, and a fervent admirer of Zeeman, "painter of sailors." Other comparisons of old and new which furnish food for thought are Muirhead Bone with his wonderful dry-point of *Building* (1904) and Piranesi's *Foundations of the Castel S. Angelo* (from the "Antichità Romane"), and Hollar's exquisite little etching of *London from the Top of Arundel House*, with the *Minster*, a wonderful piece of architectural invention and fine craftsmanship, by F. L. Griggs.

In the sphere of subject etching Rembrandt is far and away the supreme master, and my illustrations will be chiefly from his work. I am showing two of his three etched renderings of *Christ among the Doctors*, the little plate of 1631, with something of the rather forced dramatic effect of his early work, and the far more intimate and less mannered plate of 1654. Then the most famous of all his plates, *Christ Healing the Sick* (generally called the *Hundred Guilder Print*), with its wealth of imaginative insight and human observation, the *Entombment*, of 1654, of a rounded dignity of composition that undoubtedly owes something to Venetian art, and the *Christ Preaching*, often known as *La Petite Tombe*. I am showing the latter in two impressions, as a test of quality. Both show strong dry-point burr, the plate when worn out having been reworked with the dry-point by Norblin, a skilful etcher of the eighteenth century. It is the sort of impression to deceive the unwary, but a comparison with the fine early impression will at once show how lacking in unity of tone and how comparatively patchy is the re-worked state. For further comparison of quality, I have placed on the same slide an early and a later state of the *Portrait of Rembrandt with Saskia* (1636). The later state was printed from the original plate as recently as 1906, for about eighty of the plates are still in existence in Paris, having descended from P. F. Basan, a well-known engraver-printseller of the late eighteenth century, who made a good commerce in printing his Rembrandts. It is remarkable how comparatively clear the plate appears in its 1906 impression, but by the side of the early impression it will be noted how practically all the lines are coarsened by re-biting, and all the sublety of chiaroscuro is lost.

The work of etchers in the last half-century, particularly in England, has been predominantly landscape, and I am only representing two artists on the screen, Robert Spence in his *Man with the Evil Eye*, an illustration to George Fox's Journal, comparing its scheme of composition with Rembrandt's *Christ at Emmaus*, of 1654, which Spence was deliberately taking as his model; and the *Return of the Prodigal* by Forain, with its spacious design and intensity of feeling.

Finally, I am showing a series of examples of portrait etching at various epochs. Most direct and immediately convincing of all are Van Dyck's plates, of whom I am showing the *Jan de Wael* and *Pieter Brueghel the younger*. All his portrait plates are done in the same open manner of pure etching, which Rembrandt to a large extent followed in his earlier work, which was being done about the same time as Van Dyck was engaged on his *Iconography*, i.e., between 1627-40. One of the most perfect of these earlier portraits of Rembrandt is the *Young Man with Books beside Him* (1637), which I am comparing with an early *Portrait of Himself* (1857) by Degas, a conscious imitation of Rembrandt's plate. In most of his portraits of his middle and later years, Rembrandt used a much more complex system of chiaroscuro, aiming almost at a painter's tone by a close mesh of etched line. This is particularly so in the portraits of *Jan Six* (1648). I am also putting on the screen two studies from this plate, both in the Six collection at Amsterdam, the first a summary sketch in pen and ink indicating the general pose; the second a more careful study, with certain modifications which were carried out on the plate. The latter bears marks of the stylus in the main lines, showing that it had been used as the actual transfer drawing to the surface of the plate. Another plate, that of the *Old Haaring*, is one of the most characteristic examples of Rembrandt's later portrait etching, most complex in its characterisation and pulsating with life. It forms a strong contrast to the simpler handling of Van Dyck, who always emphasised some salient note, and probably achieved thereby

more convincing success by his portraits than Rembrandt, for all the Dutchman's greater depth of vision.

Finally a few recent portraits : Anders Zorn in his *Portrait of Anatole France* (1906), with its breadth of execution and luminous quality; Francis Dodd's *Portrait of General Booth*, an excellent example of his dry-point work; Gerald Brockhurst's *Mrs. Rushbury*, exquisite in its distinction of line, and Augustus John's earliest etched *Portrait of Himself* (1901).. I have placed this little plate by John on the same slide as an early Rembrandt self portrait (*Rembrandt aux Trois Moustaches*), and though quite evidently the imitative work of a young artist, it shows a quality of its own by no means unworthy of the great etcher.

Perhaps the greatest danger to recent etching has been its popularity; the public has preferred a bad etching to a good woodcut or lithograph, leaving these other arts a safer though less prosperous field. It is perhaps on that account that some of the best etchers are those who have exhibited least. But with work being done of the quality of John, Gerald Brockhurst and F. L. Griggs, to mention only three apart from those classics of etching, D. Y. Cameron, Muirhead Bone and James McBey, there is every reason to be proud of the achievement of the present day in etching.

RICE PLANTING IN SARAWAK.*

Of the many different tribes inhabiting Sarawak all cultivate rice with the exception of the nomadic tribes of the far interior. The methods adopted vary slightly but are for the most part of a primitive order.

The Dayaks and other inland tribes mostly cultivate "hill" rice, and for this purpose destroy large quantities of valuable timber every year. They consult the omens before selecting the farming lands for the year.

"Hill" land that has been farmed is allowed to lie fallow for at least seven years and "wet" land for three years.

Both men and women assist at the clearing, the women cutting the undergrowth and the men felling the big trees. These trees are often so large that it is necessary to build platforms from which the felling is done and in some cases large trees are left standing and only the branches lopped off and used to feed the fire which follows, when the dead wood is burnt to manure the soil.

The tools used for clearing are of various kinds, but the "biliong" is commonly used for felling the large trees.

The planting is done at the end of the dry season, about July and August, so that the growing crops may have the benefit of the rains and the grain have a chance of ripening in the beginning of the next fine season, about April or May. If old jungle is cleared the clearing is commenced about May or June in order that the timber may have time to dry before the burning time.

Buffaloes are not used for preparing the ground except by the Muruts, Kadayans, and others living in the districts adjacent to Brunei and also by the tribes inhabiting the highlands at the head waters of the Baram, Limbang, and Trusan rivers.

SOWING.

The seed of the hill papi is planted in holes about 1′ to 18″ apart made by a blunt pointed stick. Three or four seeds are dropped into each hole and covered by scraping earth or ashes over the hole with the foot.

Wet padi is either broadcasted or transplanted. If old jungle has been cleared the seed is usually broadcasted, but otherwise it is transplanted from nurseries when about 6″ high into holes drilled with a pointed stick.

The farms are fenced to keep out the wild pig and deer immediately after the padi commences to grow. The fences are strongly but roughly made and are generally about 6′ high. When the farms are at a distance from the village it is usual to construct a farm house in which the family lives for the time being.

The weeding is more often than not left to the women and children whilst the men go hunting or in search of jungle produce.

CATCH CROPS.

Immediately after the burning, tobacco, maize, cucumbers, bayam, egg plants, etc., are planted wherever the wood ashes are thickest. These ripen and are eaten before the padi harvest. Millet is also planted on the edges of the paths and at the edges of the farm. This is done partly to keep the monkeys occupied till the owner arrives and drives them away.

THE HARVEST.

The heads of the padi seldom ripen all together; consequently the crop is not reaped all at once, but the ripe heads are collected. The Dayaks do not use knives but strip the ripe heads with their fingers.

The padi is stored sometimes in the houses in receptacles made of the bark of large trees and sometimes in specially constructed granaries. When it is desired to convert the padi into rice it is pounded in mortars or put through a husker and then winnowed.

* Extracted from "Notes on Sarawak Trade," published by the Committee for Agricultural and Food Exhibits, Malay-Borneo Exhibition.

Crops vary greatly in quantity, the following being the usual causes of failure: an unsuccessful burning of the clearing, insufficient rain at the planting season, insufficient sunlight during the ripening period, depredations of wild animals, rats and mice, attacks of insects, etc.

Much valuable time is often wasted in the observance of "tabus," and when crops are plentiful, numerous feasts are given with the result that there is not infrequently a shortage of rice towards the end of the season. The use of large quantities of rice in the making of spirituous drinks is sometimes the cause of a shortage of food amongst the non-Mohammedan tribes.

In the absence of reliable statistics it is impossible to estimate the average yield, but a fair average for hill padi would probably be about 30 fold and for swamp padi about 70 to 100 fold.

CHINESE HAIR-NET INDUSTRY.

The hair-net business in China has had quite a history. It was established originally by Germans, who imported the nets from Chefoo into Germany and then exported them to the United States as European-made hair nets. There is still considerable export of human hair nets from China to European countries.

According to a report by the United States Consul at Tsinan, the bulk of the human hair nets supplied from China comes from the Province of Shantung, and while the shipment of such nets from Shanghai reached a total value of over £500,000 in 1921, Shanghai is only a trans-shipment port for Shantung. Chefoo, the largest producing centre sent to the United States in 1920, 856,610 gross and in 1921, 1,667,914 gross. Tsinan is the second largest producer; its shipments to the United States rose from 131,660 gross in 1920 to 512,317 gross in 1921.

When direct trade in human-hair nets was taken up with China, large quantities of imperfect, undersized, and generally poor nets were exported. This finally resulted in the establishment at Chefoo and Tsinan, by the foreign and a few larger Chinese exporters, of hair-net inspection factories, some employing as many as 1,000 operatives, where hair-net cargoes are inspected and, if necessary, the nets repaired before being shipped.

The net making itself is a home industry; the hair is distributed around in the various villages—in the hinterland of Chefoo and in the region of the Shantung Railway from Tsinan to Tsingtau—and the nets usually pass through the hands of several Chinese middlemen before they are offered by the Chinese dealers to exporters. The exporters buy the nets, inspect and repair them, and ship them. Rejected cargo which exporters refuse to take frequently finds its way to Shanghai, where native dealers attempt to sell it to exporting firms not specialising in the hair-net business and, of course, doing no inspection; so that quantities of bad cargo still find their way out of the country. Even "inspected and repaired" cargo is not entirely free from claims.

The hair-net business has been rather dull this year, due to the tendency of double nets to displace single nets This has resulted from the durability of the double net, which, it is stated, wears five to ten times as long as single nets. The Consul adds that there is no sterilising process used on human hair nets shipped from the Shantung district and no sterilisation is done on any hair nets in China.

GERMAN ARTIFICIAL FLOWER INDUSTRY.

Before the war the artificial flowers made in Germany were produced by the "cottage" industries of Sebnitz in Saxony They were made by the dozen and were not of the best quality. As the quality of these Saxon products did not compete with the high-grade artificial flowers manufactured in France, there was little fear of the Sebnitz industry on the part of foreign producers, and it was not until 1905, when the Saxon industry was about 35 years old. that a protective tariff against German artificial flowers became effective in France.

With the outbreak of the war in 1914, German exporters were able temporarily to sell cheap artificial flowers in Scandinavian and other countries, which normally were exclusively French markets for those articles. This trade only lasted a few months, however, since the raw materials necessary for the manufacture of these flowers could not be obtained in Germany. On the other hand, it was possible to purchase, particularly from Switzerland, materials, such as brocade and velvet, which are used in the manufacture of artificial flowers of the best quality. This circumstance led many German manufacturers to produce high-grade flowers, such as had heretofore been made only in France, and since that time, writes the United States Commercial Attaché, at Berlin, steady progress has been made in this industry in Germany.

In 1912 Germany exported 8,050 metric quintals of medium-quality artificial flowers, and at the present time is exporting high-grade flowers to almost all markets formerly monopolised by France. During March, 1922, Germany exported 660 metric quintals, valued at 68,528,000 marks, of which 294 metric quintals went to the United States, 265 to Great Britain, and the rest to Scandinavia, the Netherlands, and Switzerland. (Metric quintal = 220·46 lb.)

The extent to which the German industry has progressed is also shewn by the fact that scarcely any artificial flowers are being now imported into Germany from France.

GENERAL NOTES.

Drought in South Africa. — Mr. W. G. Wickham, Senior Trade Commissioner in South Africa, calls the attention of *The Board of Trade Journal* to the Interim Report of the Drought Investigation Commission, which since September, 1920, has been examining the serious problems arising out of the periodic droughts in the Union of South Africa. Mr. Wickham points out that the prevention or mitigation of drought is fundamental in relation to the future of the Union. The Commissioners emphasise the fact that nature, assisted by human agency, is at present converting South Africa into a desert, and giving rise to a much more serious problem than the eventual exhaustion of the Transvaal gold reef. Extensive areas of the Union are drying out, and a continuance of the process, if unchecked, must render South Africa, as we know it, uninhabitable by man. Two facts have been established. First, that a large portion of South Africa was dry long before the white man arrived, and secondly, that since the white man has been in South Africa great tracts of country have been entirely or partially denuded of their original vegetation, with the result that rivers, vleis, and water holes described by old travellers have dried up or disappeared The Commissioners find that the kraaling of stock, occasioned mainly by the jackal, inadequacy of the drinking water facilities, the destruction of vegetation and the resulting soil erosion, which in turn diminishes seriously the efficiency of the rainfall, are the main causes of drought losses, which in 1919 amounted to not less than 16 millions. These are the direct losses and are a portion only of the total losses which are suffered.

Carnauba Wax Exports from Brazil.— Carnauba wax, used in the manufacture of phonograph records and physical apparatus, and considered one of the best electric insulators, is a product peculiar to Brazil. While it is found as far south as Bahia, and even grows sparsely in the more temperate parts of Brazil, it thrives best (according to a United States Consular report from Brazil) in the hot, dry zones of the north-east, the chief producing States being Ceara, Maranhao, Piauhy, and Rio Grande do Norte. The total exports of carnauba wax from Brazil during the past four years have been as follows: In 1918, 4,215 metric tons, worth 20,432,956 milreis; 1919, 6,224 tons, valued at 20,539,680 milreis; 1920, 3,516 tons, valued at 10,873,046 milreis; and 1921, 3,906 tons, worth 10,394,627 milreis. The chief ports of shipment for carnauba wax are Fortaleza, in the State of Ceara, and Ilha do Cajueiro, in the State of Maranhao, the wax exports of the two States sometimes taking second and sometimes third place among all of their exports.

Wax Production in the Aden District.— After two years of inactivity, writes the United States Consul at Aden, the wax market in Aden is again active under the stimulus of a brisk demand from Europe. The largest quantities of the best wax come from the Shankalla district of Abyssinia—one of the largest honey-producing regions. The Arabian wax, which comes from the Yemen, is inferior in quality and usually adulterated with a certain kind of fat to increase its weight. The Abyssinian wax comes in hard chunks and is usually pure. Wax is not used locally, but is all exported. The Arabian merchants pack it in bags, which weight from 3½ to 4 maunds (1 maund=28 pounds) each. Imports of wax into Aden amounted to 1,593 hundredweight in 1913-14, 3,890 hundredweight in 1919-20, and 278 hundredweight in 1920-21. During the same periods the exports totalled 1,462 hundredweight, 4,089 hundredweight, and 335 hundredweight, respectively. The United Kingdom is the principal destination of the wax exported from Aden.

Reh Salts.—In the February number of the *Journal of Indian Industries and Labour* Messrs. E. R. Watson and K. C. Mukerjee, of the Technological Institute, Cawnpore, discussed the nature and extent of the deposits of reh salts in the United Provinces, and estimated that a very large quantity of carbonate of soda existed in the soil covering a large portion of that province. In the current number the same authors deal with the problem of utilizing these reh salts and give the results of various experiments conducted by them with the object of ascertaining the best methods of preparing pure soda ash, caustic soda, sodium sulphide and other products from this indigenous material. The results of these researches and the account of the methods by which they were obtained should be of much interest to industrial chemists.

Cocoa Industry of Orinoco River Delta.—About 5,000,000 cocoa palms have been planted during the past 10 years on the Venezuelan side of the Gulf of Paria, opposite Trinidad, and in the delta district of the Orinoco River. The results, according to the United States Consul in Trinidad, have been highly satisfactory, the yield per tree amounting to four pounds of cocoa, or about double what it is in Trinidad. The quality is very good, and usually the price received is about 10 per cent. higher than that paid for Trinidad cocoa. The cocoa from these districts is shipped to Trinidad, and from there it is exported to foreign countries. The export of Venezuelan cocoa from Trinidad to the United States is becoming increasingly important, amounting to 3,800,000 pounds, valued at about £120,000 in 1920, and 4,616,000 pounds, valued at about £92,000 in 1921.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE MECHANICAL DESIGN OF SCIENTIFIC INSTRUMENTS.

By PROFESSOR ALAN F. C. POLLARD, A.M.I.E.E., F.Inst.P.

LECTURE I.—*Delivered February* 20*th*, 1922.

Outside the realm of the Law, with which Science has nothing in common, an instrument is an arrangement of coacting parts which aids or supplements the senses in a qualitative or quantitative manner during the performance of experiment, and if we consider the true seat of the senses to be in the central nervous system we might classify the sense organs themselves as instruments, for indeed we find in an old book :—

"Then wash all the instruments of the sences, as the eies, the ears, the nostrils, the mouth, the tongue, the teeth and all the face, with cold water."

It is a little more difficult to understand quite what is meant by the generally accepted term "scientific instrument," though, perhaps, it might be confined with advantage to that class of instruments which definitely measure some physical magnitude.

The above definition divides instruments into two main groups :—

A. Those which aid the senses in a qualitative manner and are used for observation only during experiment, such as microscopes, telescopes, telephones, etc.

B. Those which aid the senses in a quantitative manner and are used for measurement, such as ammeters, voltmeters, micrometers, manometers, astronomical transits, depth gauges, scleroscopes, etc., etc.

This last group is by far the largest and most important for it is the last stage in the natural evolution of the instrument as it moves during its growth from the conceived idea through the stage of qualitative use and experience, and the factors of this evolution are closely bound up with those of the evolution of man himself and all his activities. The fields of this growth are the laboratory and workshop and it frequently happens that the instrument of research to-day is the tool of industry to-morrow.

The design of scientific instruments embraces the application of many branches of the physical, engineering and chemical sciences as well as of the art of manufacture.

It embraces the application of physical and engineering laws to the arrangement and proportioning of instrument components for the performance of some specific function.

It calls to its aid the chemist for the suitable choice of materials of construction and it must conform to the art of manufacture so that the cost of production shall not throttle its inception.

The design of an instrument after the birth of its concept during the stages of the first modelling to the possibilities of actual construction demands chiefly considerations of a physical nature.

Later, as the design passes to the stages of serviceable construction, manufacture and, possibly, later still to the final stage of mass production, the considerations are chiefly of a mechanical, engineering, and economical nature.

It is to this later stage in design that these lectures are in small part directed.

The fundamental principles of the construction of all instruments have been laid down by Maxwell,* and so important are his words that they are worthy of being quoted in full. He states :—

"There are certain primary requisites, however, which are common to all instruments, and which, therefore, are to be carefully considered in designing or selecting them. The fundamental principle is, that

* *Handbook to the Special Loan Collection of Scientific Apparatus.* 1876. p. 3.

the construction of the instrument should be adapted to the use that is to be made of it, and in particular, that the parts intended to be fixed should not be liable to become displaced; that those which ought to be movable should not stick fast; that parts which have to be observed should not be covered up or kept in the dark; and that pieces intended to have a definite form should not be disfigured by warping, straining or wearing.''

These apparently simple but pregnant words of Maxwell's may be regarded as the five fundamental axioms of design, and those who know of these axioms are aware of the difficulty of satisfying them in any one instrument.

Maxwell continues :—

''Each solid piece of an instrument is intended to be either fixed or movable, and to have a certain definite shape. It is acted on by its own weight, and other forces, but it ought not to be subjected to unnecessary stresses, for these not only diminish its strength, but (what for scientific purposes may be much more injurious), they alter its figure, and may, by their unexpected changes during the course of an experiment, produce disturbance or confusion in the observations we have to make.

''We have, therefore, to consider the methods of relieving the pieces of an instrument from unnecessary strain, of securing for the fixed parts a determinate position, and of ensuring that the movable parts shall move freely, yet without shake.

''This we may do by attending to the well-known fact in Kinematics :—

'*A rigid body has six degrees of Freedom.*' A rigid body is one whose form does not vary. The pieces of our instruments are solid, but not rigid. They are liable to change of form under stress, but such change of form is not desirable, except in certain special parts, such as springs.

''Hence, if a solid piece is constrained in more than six ways it will be subject to internal stress, and will become strained or distorted, and this in a manner which, without the most exact micrometrical measurements, it would be impossible to specify.

''In instruments which are exposed to rough usage it may sometimes be advisable to secure a piece from becoming loose, even at the risk of straining and jamming it, but in apparatus for accurate work it is essential that the bearings of every piece should be properly defined, both in number and in position.''

Before considering the kinematical proposition that a rigid body has six degrees of freedom, we must make ourselves acquainted with what is meant by a kinematical degree of freedom.

Consider a point in space. It has no dimensions and cannot therefore enjoy rotation. It has no parts and therefore only one aspect, i.e., position when viewed from any direction.

Its position in space must be referred to a frame of reference, to a system of co-ordinates.

And if we refer it to the cartesian or rectangular co-ordinate system, its most general displacement can be resolved into three motions, *i.e.*, translations along or parallel to the three directions or axes x. y, z, of the frame of reference, which are independent of one another. These are its three degrees of freedom. If one of these is fixed in magnitude, say $x = a$ constant a, the point is confined in its movements to one plane, *i.e.*, the plane parallel to the y and z co-ordinates. It can now move in that plane only, parallel to the two directions y and z. It has now, therefore, two degrees of freedom and has had imposed upon it one degree of constraint. If the point is further constrained to move on another plane, say that of $y = b$, it can only move in the first plane and in the second at the same time by moving along the intersection of these two, *i.e.*, in the one direction parallel to z. Consequently it has now only one degree of freedom and two degrees of constraint. If the third and last degree of freedom be removed, z must be assigned a constant value c and the three equations

$$\left.\begin{array}{l} x = a \\ y = b \\ z = c \end{array}\right\}$$

represent a fixed point, *i.e.*, that which is common to the intersection of all three planes. Our point has now no degrees of freedom and it has imposed upon it three degrees of constraint. It is therefore fixed.

So far we have referred to plane surfaces, but constraint may be imposed in other ways.

Instead of using rectangular co-ordinates we might have taken polar co-ordinates and assigned the condition in a single equation that the point should be confined in its movements to the surface of a particular sphere. By doing this we should be depriv-

ing the point of one degree of freedom, for now it can only move in latitude and longitude on the spherical surface, and these are its two remaining degrees of freedom. In general a degree of constraint can be expressed by equating some function of the point's rectangular co-ordinates to a constant. This equation then represents a surface on which the point may lie. Three such equations will fix the point or rob it of its three degrees of freedom, for now it can only lie at the point or points where the surfaces intersect.

If the constant of any one equation be variable then the equation represents different surfaces of that particular family.

Thus it will readily be seen that the three constants, if variables, are themselves co-ordinates of the point and are spoken of as "generalised co-ordinates." So that in this sense the point has still three degrees of freedom. Instead of being regarded as having a degree of freedom along a straight line in space, it has freedom over a surface, and it requires three such surfaces to fix it.

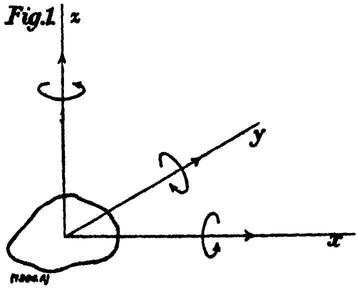
The mathematical transformation of the general equations from Cartesian to generalised co-ordinates form one of the most powerful and elegant contributions to abstract dynamics which the genius of Lagrange achieved.

Let us now consider a rigid body. As Maxwell has said, no body in nature is rigid but yields elastically to applied forces. But for our present purpose we may ignore the small movements due to elastic change of shape and regard all bodies as rigid. A rigid body, unlike a point, has dimensions and can therefore rotate about some axis.

This condition at once introduces three more degrees of freedom.

The most general motion of the body (Fig. 1) may now be resolved into three rotations about the axes x, y, z, in space as well as translations along them, and these are its six degrees of freedom.

Fig.1



Now suppose we fix a point of the body: then we see that it has lost three degrees of freedom, for it cannot move along the three axes, but it can still rotate about the three axes which pass through the fixed point. So that it has three degrees of freedom left which, together with the three degrees of constraint, make up the six elements. The fixed point may, in general, be a point of a continuous surface of the body in contact with a continuous fixed surface, but it must be supposed that no sliding takes place between the surfaces.

This condition is realised in practice by the ball and socket joint of which the centre is the fixed point; so that such a joint enjoys three degrees of freedom. If two points of the body be fixed, the body loses two more degrees of freedom, for now it cannot rotate about two of the axes, *i.e.*, those perpendicular to the line joining the two points.

It has, therefore, one degree of freedom left—it can only rotate about the line joining the two points.

If a third point not in line with the other two be fixed the body is completely constrained.

Now, when one point of the body was fixed, we robbed it of three degrees of freedom, but if we allow the point to move in any direction over a fixed surface, we give it back two more degrees of freedom.

If, therefore, a rigid body be forced to move in contact with a fixed surface, it loses one degree of freedom, *i.e.*, it cannot move normally to that surface and it has five degrees of freedom left. Every successive constraint of a point in the rigid body to a surface means an additional loss of a degree of freedom, and thus six such conditions completely fix the body.

Thus, if six points properly chosen on the barrel and stock of a rifle be made to rest on six convex portions of the surface of a fixed support, the rifle may be replaced any number of times in precisely the same position for the purpose of testing its accuracy.

Design which is guided by these principle[8] is termed *geometrical design*, and it may possibly already be seen that such design in many cases will eliminate accurate fitting with its attendant troublesome manufacturing allowances and tolerances, and will reduce the number of functional surfaces to a minimum. By thus introducing the various constraints we require,

in accordance with geometrical and kinematical principles, we achieve good design, and we shall see in the sequel that we can reduce the cost of production to a remarkable degree, whilst retaining precision of adjustment unobtainable in any other way.

The number of ways in which geometrical design can be applied is unlimited, and yet it would appear that this part of our subject is not so well understood as its great merits deserve. We shall, therefore, devote a good deal of our time to the description of the various parts of instruments which have been successfully designed on these principles. and in some cases examine the defects of the design where these principles have been violated.

Let us start with the case in which the instrument or a part of it is required to be placed in a definite position.

This will require a means of applying and maintaining six mutual pressures between the part and its support touching one another at six points. Such an arrangement is spoken of as a *geometrical clamp.*

An old and well-known form of geometrical clamp, with the six pressures produced by gravity is the three V grooves on the support bearing the legs of a theodolite or magnetic instrument. (*The lecturer here showed a model.*)

The arrangement of the surfaces is important. If one of the surfaces be removed, the corresponding point of the instrument (which now has a degree of freedom) will move in a direction determined by the other bearings. The tangent plane at the bearing should be as nearly as possible square to the direction of this possible movement. This condition implies that no two normals to the tangent planes at the bearings shall coincide, that no three shall be in one plane, and either meet in a point or be parallel, or more generally belong to the same system of generators of an hyperboloid of one sheet. The conditions for five or six normals are more complicated.

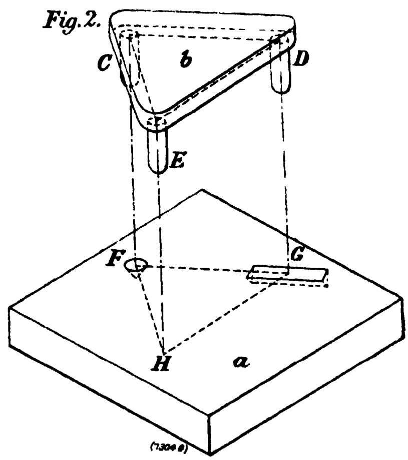
The three grooves arrangement, generally speaking, is not so well conditioned as Kelvin's clamp.

In his clamp one of the feet rests in a V groove and another in a trihedral hollow in line with the groove, whilst the third foot rests on a plane. (*The lecturer here showed a model.*)

Here, again, there are six surfaces, and the pressures between them and the feet are produced by gravity.

One of the bearing points is on the plane, two are on the sides of the groove, and three on the sides of the trihedral hollow. Substitute for gravity a spring or a light screw and nut binding the part to its support to which those six planes belong, and we have a geometrical clamp which maintains a geometrical relation between the two far more securely and precisely than the clamps usually used by mechanicians with three strong screws forced to the utmost. A trihedral hole is difficult to make, and for most practical purposes a conical hole may be used in place of it. In Fig. 2, *b*

Fig. 2.



represents the instrument with its three rounded feet C, E, and D, and *a* represents the support with the plane at H, the groove at G and the conical hole at F, but I cannot do better than quote Kelvin's* words as to the possible violation of the kinematical principle when using the conical hole. He says :—

"A conical hollow is more easily made (as it can be bored out at once by an ordinary drill) and fulfils nearly enough for most practical applications the geometrical principle. A conical or otherwise rounded hollow is touched at three points by knobs or ribs projecting from a round foot resting in it and thus again the geometrical principle is rigorously fulfilled. The virtue of the geometrical principle is well illustrated by its possible violation in this very case. Suppose the hollow to have been drilled out not quite 'true,' and instead of being a

* *Treatise on Natural Physiology*, by Sir William Thomson and Peter Guthrie Tait. 1890. Part I., p. 152. Footnote.

circular cone to have slightly elliptic horizontal sections:—A hemispherical foot will not rest steadily in it, but will be liable to a slight horizontal displacement in the direction parallel to the major axes of the elliptic sections, besides the legitimate rotation round any axis through the centre of the hemispherical surface: in fact, on this supposition there are just two points of contact of the foot in the hollow instead of three. When the foot and hollow are large enough in any particular case to allow the possibility of this defect to be of moment, it is to be obviated not by any vain attempt to turn the hollow and the foot each perfectly 'true'—even if this could be done the desired result would be lost by the smallest particle of matter, such as a chip of wood, or a fragment of paper, or a hair getting into the hollow when, at any time in the use of the instrument, the foot is taken out and put in again. On the contrary, the true geometrical method (of which the general principle was taught to one of us by the late Professor Willis thirty years ago) is to alter one or other of the two surfaces so as to render it manifestly not a figure of revolution, thus:—Roughly file three round notches in the hollow so as to render it something between a trihedral pyramid and a circular cone, leaving the foot approximately round; or else roughly file at three places of the rounded foot so that horizontal sections through and a little above and below the points of contact may be (roughly) equilateral triangles with rounded corners.''

If now we remove one of the planes we give the part one degree of freedom, and such an arrangement is termed a ''geometrical slide.'' If, for example, in the above case we replace the groove by a plane so that now the two feet rest on the plane and the third remains in the conical hollow we have a ''slide.'' The first application of this form of slide—in which the single degree of freedom is rotation about a vertical axis—was to the ''azimuth mirror,'' an instrument of Kelvin's, which is placed on the glass cover of a compass to take the azimuth of the sun or stars to correct the compass.

The movement can be made very frictionless when the plane is horizontal by loading the instrument so that its centre of gravity is nearly over the foot which rests in the hollow.

The familiar support of the trunnions of telescopes in V-shaped bearings when the trunnions are prevented from end play, is also an example of the geometrical slide.

It should be noted that this movement between the two pieces is precisely that of a journal in its bearing, it is precisely similar to that of the *turning pair* of mechanism. The extensive surfaces of contact in the turning pair of mechanism between the cylinder and the hole within which it fits have been replaced by point contacts on five surfaces. The allowance necessary for the sliding fit of the journal in its bearing is frequently responsible for a peculiar type of hysteresis which we shall meet with when discussing the ''variance'' of measuring instruments.

This hysteresis error is greater the greater the want of good fit of the turning pair and good fit in turning pairs which are manufactured in quantity require the upkeep of limit gauges and are costly to produce.

The geometrical slide is kinematically exact; there can be no variance from want of good fit, its manufacture requires no costly system of limit gauges, and its cost of production is reduced to a minimum.

The five surfaces against which five points of the moveable body are pressed can be so arranged that the single degree of freedom left is a translation instead of a rotation, and there are many applications of this form now in existence.

If we remove one of the surfaces of the trihedral hollow of Kelvin's ''hole slot and plane'' and convert it into a V groove parallel to, or better, in line with the other groove, we are again left with five surfaces and the single degree of freedom is now a translation parallel to the grooves.

An application of this form of design was made by Kelvin* to the mechanism for the precise movement of the fourth quadrant of his electrometer.

A convenient form of the geometrical slide for manufacture, is that in which a horizontal cylindrical rod forms part of the moveable body and rests upon and slides in the two V grooves of the support. (*The lecturer here showed a model.*) In this way four points of support are secured, whilst a fifth point of the moveable body rests upon and slides along a plane on the support. A modification of this form is sometimes convenient, and consists in fixing the cylindrical rod to the support and forming the grooves in the moveable part.

**Report on Electrometers and Electrostatic Measurements B.A. Report for* 1867.

(*The lecturer here showed a model.*) The only parts which have to be accurately made in these two forms of the slide are the cylinder and plane, the latter being parallel to the axis of the cylinder. The grooves may be quite roughly made, as well as the fifth point of the moveable body without in any way interfering with the accuracy of the movement.

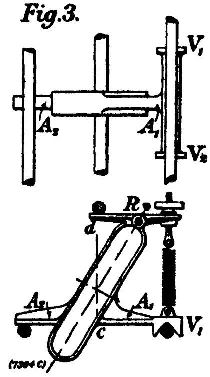
It will at once be seen how important this is from the manufacturing point of view, for it is a simple matter to grind or lap a true cylinder and plane, compared with the fitting of composite functional surfaces. It does not matter what the radius of the cylinder is as long as it is a cylinder, nor does it matter where the plane is placed as long as it is parallel to the axis of the cylinder when resting in the V grooves. The cylinder in the one case is moveable, and in the other fixed and these two forms of the geometrical slide are of service in showing how a design can be carried out in different ways.

Frequently, such alternative designs are of great utility in considering the loads to be moved, the distances through which the pieces are moved, and the amount of possible wear

A variant of the second form of the geometrical slide described above, is that applied by Professor Dalby* to give easy and smooth movement to a certain pulley in his transmission dynamometer.

In this case, the frame A_1A_2R, Fig. 3, which houses the pulley, has the two grooves V_1 and V_2 formed upon it, making contact with a fixed vertical rod at four points. The fifth point is secured by a plane A_2 of the frame bearing on a second rod parallel

Fig.3.



to the first. At R a lever is hinged to the frame, which by being forced against a third rod parallel to the other two, by means of a spring attached to the frame maintains the necessary pressure in all positionsbetween the five surfaces V_1, V_2 and A_2, and the rods, even if the rods are not quite parallel to one another. It should be noted that there can be no strain between the coacting parts in these designs during change of temperature, for there is freedom of differential movement in any direction, though the relative movement of the two parts is constrained to that along one definite axis.

A very ingenious and striking example of the geometrical slide is afforded by the recent design of the supports for the projecting microscope and condenser systems of that magnificent instrument--the Einthoven String Galvanometer, made by the Cambridge and Paul Instrument Company. (*The lecturer here showed the instrument.*)

As the means of support for the two systems are identically the same, it is only necessary to describe one of them. The fixed parts are a carefully ground

Proc. Inst. Civil Engineers, Vol. cxxxii., p. 47

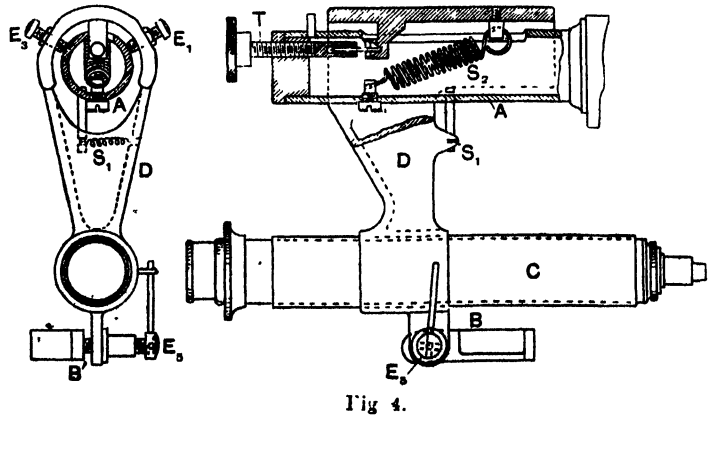


Fig 4.

cylinder A and a plane B, shown in Fig. 4, which represents the part section in side and end elevation of the projecting microscope system. The microscope C is attached to the frame D, which makes contact with the cylinder A at four points by means of the four screws E_1, E_2, E_3 and E_4. These four contacts are maintained by gravity assisted by the vertical component of the force of the stretched sloping spring S_2. The horizontal force component of this spring serves to maintain contact between the frame D and the end of an adjusting screw T, rotation of which will cause the frame and microscope to move accurately parallel to the axis of the cylinder A. To prevent the possible communication of wobble of the screw T to the frame, a short connecting rod is inserted between the two pieces. We shall return to this detail of design later. The fifth point of contact is made by the end of the screw E_5 against the plane B and is kept in contact with it by the spring S_1.

With this simple arrangement it will be seen that the most precise setting of the microscope axis can be achieved. It can be made parallel to the axis of movement, *i.e.*, the axis of the cylinder A by the screws E_1, E_2, E_3 and E_4, and it can be made to cut the "string" of the instrument when in a state of repose by the screw E_5. The only setting which has to be done in manufacture is that of securing parallelism between the axes of the two cylinders A on either side of the "string" for the microscope and condenser systems respectively, and in this particular case it is not even necessary to set the two planes B accurately parallel to the axes of the cylinders.

If this beautiful design be compared with the older design of this part of the Einthoven String Galvanometer, it will be apparent how very much more simple it is to manufacture. Its advantages over the older design as far as the user is concerned are those common to all geometrical designs, *i.e.*, the comparative cheapness of production, the perfection of the relative movement required and the utter unimportance of unavoidable wear on account of the possibility of all necessary adjustment.

Other examples of the geometrical slide applied to the design of scientific instruments are to be found in several of the productions of the Cambridge and Paul Instrument Company, some of which have been described by R. S. Whipple.* In particular, I cannot refrain from calling attention to the beautiful design of the slide for the carriage of the large cathetometer made by this firm, and it will be noticed that the point contacts have been purposely expanded into small functional surfaces, for the purpose of sustaining loads under which so-called point contacts might become permanently deformed. We shall return to this question of the point contact in geometrical design later.

Of all the smaller manufactured scientific instruments in which the relative movement of the parts must be of the highest order of precision, possibly the Michelson and Fabry and Perot Interferometers made by Adam Hilger, Ltd., stand pre-eminently first.

It is sufficient for our purpose to state that the chief object of the mechanism in these instruments is to move an optical mirror along an axis of some ten inches in length with such accuracy that the normal to the mirror will not wander about its mean direction when the mirror is at any part of the slide by more than 5.10^{-6} of a radian.

The carriage which carries the mirror is geometrically constrained to move along the slide which is a steel forging of channel section, with the slide surfaces formed in the upper and one of the side faces. These slide surfaces are worked to an *optical flat*, and the carriage for the mirror has a three point contact with the upper surfaces and a two point contact with the side surfaces maintained by suitable spring pressure upon the opposite surfaces of the slide, which need not, of course, be very carefully formed. This is the usual disposition for a geometrical slide, but the particular point of interest to us is the form and extent of the so-called point-contact surfaces of the carriage These surfaces are small cylindrical studs let into the carriage with their exposed flat ends bearing against the steel slides; but in order that dust shall not collect between the sliding surfaces and tilt the mirror, it has been found necessary to clear away the metal from the central portion of the stud surfaces so as to leave an annulus of metal in contact with the surface of the slide.

The simplicity and cheapness of production of most forms of geometrical design, however, is due to the fact that the constraint is produced by the pressure of a point against a surface, and therefore at the most only two of the elements of constraint have to be carefully worked, not with the object of accurate fit, but with the object of accurate

* *Trans. Optical Soc.*, Vol. xxii., p. 35.

geometrical shape which, from the constructive point of view, is an entirely different proposition. As a rule the worked surfaces take the form of cylinders or planes which can be comparatively cheaply produced by grinding to sufficient accuracy for most purposes.

Now it must be clearly understood that this so-called point of contact is not a geometrical point at all, but a definite area the dimensions of which depend upon the pressure, the form of the elements in contact and the elastic constants of the materials. Hertz* was the first to give us a mathematical expression for the dimension of this area as well as to show in what way the stress is distributed about the point of contact between the two bodies. The matter was taken up later by Huber and Fuchs, and recently Professor W. B. Morton** and L. J. Close have contributed a paper on this problem of considerable importance to the geometrical design of scientific instruments, as well as to some questions in metrology.

When the pressure is greater than one point can conveniently stand the geometrical design can frequently be pushed to more than one point of contact for a given constraint.

But immediately we do this the geometrical principle is violated and at once it becomes necessary to introduce accurate and more expensive manufacture.

Cylinders, planes and spheres can be cheaply and accurately manufactured, however, so that construction of instruments can be greatly simplified by this application of compromised geometrical design.

A good example of this is shown in the use of the sphere cylinder and plane in the slide of the carriage of the Wickman Universal Gauge measuring machine, made by Messrs. Alfred Herbert, of Coventry.

In this machine the top carriage, which weighs 75 lbs., moves accurately along an axis over nearly four inches.

Fig. 5a shows the under side of the top carriage and Fig. 5b the top surface of the main bed, and the relative motion takes place between these two parts. On the latter, two pairs of ¾ inch hardened ground and lapped steel cylinders are mounted as shown in suitable seatings. On the under side of the top carriage a similar pair of cylinders and a hardened, ground and lapped steel flat are mounted and so placed

*Miscellaneous Papers (English Trans.) p. 146.
**Phil. Mag. Vol. 43, 1922, p. 320.

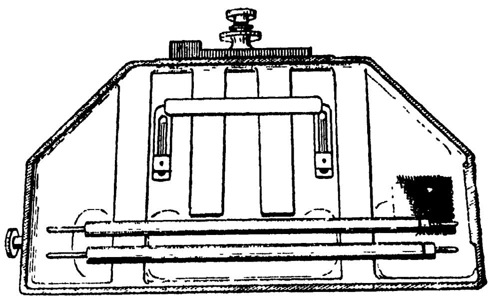


Fig 5a.

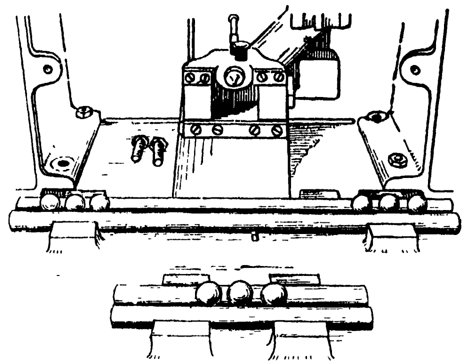


Fig. 5b.

that when the top carriage is positioned upon the main bed the two pairs of longer cylinders come opposite one another and the flat faces the middle line of the pair of shorter cylinders. To complete the slide all that is necessary is to insert two balls between the two opposite pairs of cylinders and one ball between the other pair of cylinders and the flat. There are thus five points of contact between the balls, cylinders and flat of the top carriage, whilst the cylinders of the main bed merely guide the balls when motion takes place.

In the actual example before us the number of balls has been increased to nine in three groups of three each, to reduce the pressure at each point of contact.

In spite of the weight of the top carriage the makers state that it only requires the pull of 1½ ozs. weight to set it in motion, and consequently not only is the movement truly rectilinear, but what is equally important, the pressure on the measuring anvils can be made extremely light.

It will be noticed that the two castings require no accurate machining, and it is a comparatively simple matter to secure parallelism between the elements on each.

If still greater pressures have to be taken by the relatively moving parts the point contact can be made plane contact. But

we then increase the difficulties and cost of production, for now the surfaces of constraint are true component functional surfaces of ordinary mechanism and in order that the virtue of geometrical design shall be maintained in so far as the elimination of unnecessary strain and aberrations in the geometrical relation of the parts are concerned, these surfaces must fit accurately in all positions of the moving piece.

A good example of this is the ordinary V and plane of the bed of a lathe for the traverse of the saddle and loose head stock, so familiar to most of us.

It frequently happens that in the design of an instrument extremely accurate slide motion is required with a minimum of frictional resistance in which the moving part has considerable weight or is subjected to large forces tending to separate the pieces. I have known cases in which the instrument has had to be abandoned on account of the excessive forces required to set the pieces in relative motion and which would introduce aberrations in the recording mechanism, and undesirable wear. The general question arises as to whether it is possible to replace the sliding pair entirely by turning pairs, and I think a general answer can be found in Sarrut's mechanism.

It is commonly believed that the production of a straight line motion was impossible until the problem was solved by the invention by Peaucellier of his inverting cell. But eleven years before Peaucellier's announcement, Sarrut in 1853* solved the more complete problem. All the straight line motions which were produced after and stimulated by Peaucellier's invention gave rectilinear motion to all the points of a line in one of the pieces parallel to the hinge-lines, or else to all points of a hinge-line connecting two pieces. Sarrut's solution, which embraces Peaucellier's invention, gives rectilinear translation to a whole piece.

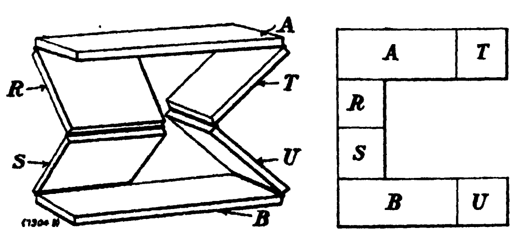


Fig. 6.

The mechanism may be briefly described as follows:—In Fig. 6 the pieces A and B are connected together by means of the four pieces R S T and U, which, when separated at T U and spread out on the flat, appear as shown in the diagram to the right.

The pieces R and S are connected together and to the pieces A and B by means of three parallel horizontal hinges. The pieces T and U are also connected together and to the pieces A and B by means of three parallel horizontal hinges whose common direction differs from that of the former three hinges. It is readily seen that the piece A will have rectilinear motion with regard to B, and what is important from a constructional point of view, the pieces A and B are rigidly parallel to one another throughout the whole motion.

If A, therefore, represents a part of an instrument which is required to slide with regard to the frame work B, we have here a satisfactory means of replacing the sliding pair by wholly turning pairs represented by the hinges in the model. (*The lecturer here showed a model*).

There can be no doubt that Sarrut's mechanism, which was not appreciated for 50 years until Bennett* generalised upon it in 1905, will play an important rôle not only in instrument design, but machine design of the future.

Bennett's generalisation of Sarrut's mechanism is of considerable interest and should be noted, though its practical application may not be of much utility at present. Bennett points out that as seven is the normal number of pieces in a closed kinematic chain necessary to ensure freedom of one degree, the mechanism of Sarrut belongs to a special class of mechanisms, with only six pieces possessing singularly and exceptionally one degree of freedom.

He finds that Sarrut's mechanism is a special case of the more generalised form shown in Figures 7 and 8. The pieces A B are connected together by means of the hinged pieces R S T and U as before, but if the axis of the hinges connecting A R S B meet at a point X and the axis of the hinges connecting A T U B meet at Y, then the piece A will have a motion of pure rotation relative to B about the line X Y. (*The lecturer here showed a model.*)

The mechanism, like Sarrut's, possesses one degree of freedom, and is made up of six pieces, and it is useful to note that it may be regarded as composed of two

*Comptes Rendus, Paris, 1853, Vol. XXXVI.

*Phil. Mag. Vol. ix., 1905, p. 803.

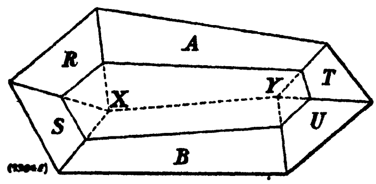


Fig. 7.

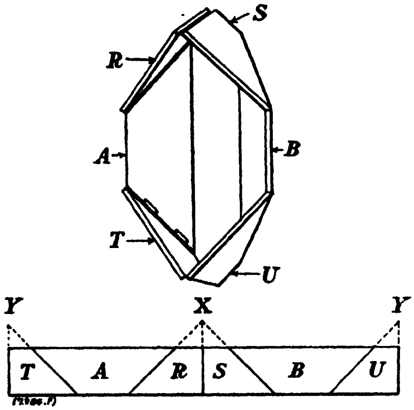


Fig. 8.

spheric mechanisms each of four pieces, placed in tandem with different centres.

If now the hinges connecting A R S B and those connecting A T U B be made parallel, the points X and Y go to infinity, the piece A rotates relatively to B about an axis at infinity, *i.e.*, A has rectilineal motion relative to B, and Sarrut's mechanism is the result.

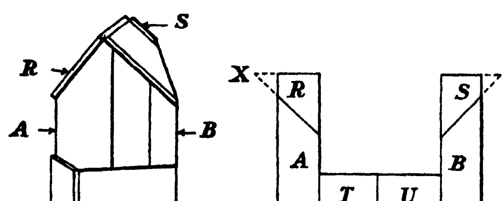


Fig. 9.

If only one of the points, say Y (Fig. 9) is sent to infinity by making the hinges of the pieces A T U B parallel, we get a third mechanism, in which the piece A rotates relatively to B about a line parallel to the hinges of pieces A T U B, and passing through the point X, the meet of the other hinges. (*The lecturer here showed a model.*)

Although Sarrut's invention is even now not generally known, it is interesting to observe that it did not escape the general fate of all inventions. It was reinvented more than once.

In 1880 Brunel took out a patent for it,* and in 1891 Professor Archibald Barr again invented it.**

We should do injustice to this part of our subject if we omitted to mention the ingenious microscope which was constructed upon geometrical principles by the late Dr. Keith Lucas when a boy at Rugby School between 1893 and 1898, in a home workshop during the holidays with a scanty supply of materials and few tools.

This instrument which I have here has been lent to me for these lectures by Mrs. Keith Lucas, to whose kindness I am much indebted. It has been described by the designer in the "Journal of the Royal Microscopical Society," 1904, p. 272, but it will be instructive to examine the main features of the mechanism for the coarse and fine adjustments as well as the efficient substage with its simple, roughly made, and yet precise arrangements.

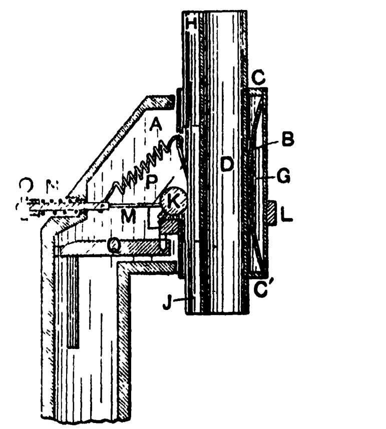


Fig. 10.

For the purpose of the coarse adjustment the body tube D, Fig. 10, passes through the shorter and larger tube B, at each end of which is a ring C and C^1. Each of these rings has two projections, Fig. 11, which serve as bearing surfaces for the tube D.

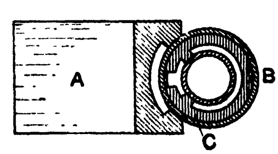


Fig. 11.

Between the two tubes a leaf spring G, Fig. 10, lies, which presses the tube D against the four bearing surfaces. This tube has

*Patent Spec. 5492, Dec. 30.
***Proc. Phil. Soc.*, Glasgow, March 18, 1891.

thus two degrees of freedom left—translation parallel to its axis and rotation about its axis. The latter freedom is constrained by a piece of smaller tube H, soldered parallel to the back of the tube D, passing through and engaging with a slot in the upper ring C, Fig. 11.

The coarse adjustment is effected by means of a wire J, Fig. 10, and cylindrical piece K integral with the larged milled heads on either side of the instrument.

The two ends of the wire are fixed to the extreme ends of the tube D, and the wire lies within the smaller tubes. The upper end is fixed through a spring held in tension (between 5 lbs. and 6 lbs.). The wire, which will stand a breaking strain of 22 lbs., takes one turn round the cylindrical piece K. This piece has its bearings in a ring L, which embraces the large tube B. The friction of the wire round the cylinder K is sufficient to cause the up and down movement of the body tube when the milled heads are turned.

Such an arrangement has three advantages:

(i) Small cost of construction;

(ii) The pull is in the direction of the desired movement of the tube and there is no outward thrust such as is caused by a rack and pinion;

(iii) The motion is smooth and regular.

For the fine adjustment the design is as follows:—

The limb A partially embraces the large tube B and carries four projections, two at its upper, Fig. 11, and two at its lower end, against which the tube B is pressed by means of the rod M, Fig. 10, hinged to the ring L, and passing backwards through a hole in the back part of the limb where it is secured by a nut O and spring N. The hinged joint, whose axis is horizontal, allows the tube B to move up and down through a small distance as the rod moves in or out of the hole in A. The rod thus constrains the possible rotation of the tube about its axis.

The spring P in tension between the upper part of the tube B and the more remote end of the rod performs two functions. The horizontal component of the tension is added to that of the spring N and keeps the tube pressed against its four bearing surfaces. The vertical component urges the whole tube together with the entire coarse adjustment and body tube downwards against the end of the lever Q, shown in side view in Fig. 10, and end view in Fig. 12. This lever is of the bell-crank type, with its axis of rotation running from back to front of the limb, and bears at the lower end of its long lever against the end of a fine threaded screw, the milled head of which, situated at the left of the limb, serves as the fine adjustment.

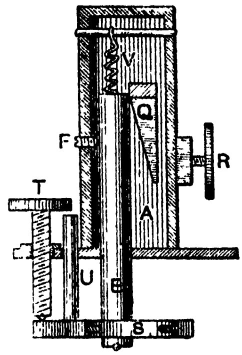


Fig. 12.

The substage consists of a long tube E, Fig. 12, and a bracket S, attached to it, extending laterally to encounter the focussing screw T and forwards to carry the centreing ring into which the condenser is fitted. The lateral extension also carries a rod U mounted parallel to the tube.

The whole substage is urged upwards against the focussing screw by a long spiral spring V anchored to the limb at its upper end, and passing through the tube E to which it is attached at its lower end.

The upward pull of the spring and downward thrust of the screw tend to cause the substage to rotate about the lower end of the latter. This couple holds the tube against its four bearing surfaces, the upper and lower pairs of which are placed on opposite sides of it. The upper pair of bearing surfaces is formed by the ends of two screws, one of which is shown at F, and the lower pair by the sides of the hole in the stage through which the tube loosely passes.

The screws, F, allow alignment of the axis of translation of the whole substage to be made optically, with greater accuracy than could be obtained mechanically.

Rotation of the substage is prevented by the rod U which passes through a hole in the stage plate. The rod makes no attempt to fit the hole, but is pressed against one side of it only, by the spring V, which is wound up for this purpose.

The spring thus causes the substage to follow its focussing screw without backlash, holds the tube against its four bearing surfaces, prevents rotation of it about its vertical axis, and allows alignment of the substage slide with the body tube.

The connection between the screw and substage is effected by a long pointed pin which passes up inside the screw so that any wobble or shake of the screw will not be communicated to the substage.

The substage bracket is not a complete ring, but a fork open at the front. This enables the centreing ring to be readily removed. When in place, this ring is held against its two centreing screws by a spiral spring stretched between the two prongs of the fork.

The advantages of this type of design are:—

(i) Cheapness of manufacture, the turning or grinding of the tubes and the filing of the bearing surfaces being less costly than the planing or broaching and fitting of dove-tail slides.

(ii) It is impossible for the movements to become shaky from wear, since every movement is held up by a spring.

(iii) The alignment of the several slides is obtained optically.

(iv) All parts are easily removed for cleaning.

This last is an extremely ·mportant point n design, which is frequently forgotten, and is consequently the cause of much annoyance to the scientific investigator, and expense in upkeep to the user of industrial instruments.

As far as I am aware, this model is the first instance in which the principles of geometrical design have been applied to the construction of the microscope, with, I think you will admit, marked success, and I am glad to be able to say that Mrs. Keith Lucas has now presented this historical instrument to the Science Museum at South Kensington. The model is rough, but it indicates a way to correct design. The microscope is the key instrument of a key industry and there possibly does not exist a more universal or more important instrument as far as the optical industry of this country is concerned.

A short acquaintance with the recent history of the mechanical construction of the microscope is sufficient at once to bring to light a state of extraordinarily erratic evolution in design pulled up here and there with retrograde steps.

At the present time probably no critical worker is wholly satisfied with any existing design and has his own ideas incorporated in some new construction.

With the mass produced instrument the state of affairs in many cases is very bad.

I have seen the bracket which carries the substage slide packed up with paper so as to bring the fitting into alignment with the tube and further to allow of side adjustment, the clamping screw holes actually file drawn in the roughest manner.

In the first place this is evidence of want of a proper system of gauging in the mass production shop and in the second place a violation of the principles of design.

The workmanship of Adam, Jones, Martin and other famous makers of this instrument in the later half of the 18th century, was second to none in the world, and this country has kept that reputation in the hand-made instrument ever since.

But a change has slowly taken place in the mechanical arts—mass production or interchangeable manufacture is now essential to secure a world market.

We shall see later, that interchangeable manufacture, which means the production of any number of pieces all exactly alike within certain unavoidable small differences, implies amongst other things a system of limits and gauges. It is essential then that the design be based on sound geometrical and kinematical principles in which the number of functional surfaces, and hence the necessary limits and gauges, are reduced to a minimum.

This is precisely geometrical design.

OBITUARY.

Sir Charles Santley.—The Society has lost a Fellow of very long standing, by the death, on September 22nd, of Sir Charles Santley, who was elected in 1875.

Santley was born in Liverpool in 1834. The son of an organist there, he learnt to play the violin at a very early age. After a brief experience as book-keeper in a firm of leather and hide factors, he decided to devote himself to the study of music, and at the age of twenty he set off to Milan, with a capital of £40. His student days were a time of great struggle, but he had a good friend in his teacher, Gaetano Nava, and he made his first professional appearance at Milan in the opera "La Traviata," in 1857. Some other engagements followed, but he returned to England at the end of the year

quite penniless. He was then, however, heard by John Hullah, who gave him an engagement in Haydn's "Creation." His first appearance in the title part of "Elijah," a role with which he came to be so closely identified, followed soon afterwards, and led to his engagement with the Pyne and Harrison opera company, at Covent Garden, in 1859.

Santley's first appearance in Italian opera in England took place at Covent Garden in 1862, as the Count di Luna, in Verdi's "Trovatore." He subsequently transferred his services to the Mapleson management, appearing in a varied list of characters, including that of Valentine at the first performance of "Faust," which was conducted by Gounod, at Her Majesty's Theatre, in 1863. In this he achieved so much success that the composer, when the English version was brought out a year later, wrote the beautiful number known as "Di possente." specially for him

In 1861, he appeared at the Birmingham Festival in the part of Elijah, and from that time onwards he took part in almost every festival of any importance. In 1906 he made his forty-ninth appearance at the Handel Festival, and in the following year was celebrated at the Royal Albert Hall, the jubilee of his first appearance as a public singer, when in the presence of an enormous and enthusiastic audience he was presented with a cheque for £2,000, which had been publicly subscribed. He was knighted by King Edward in the same year.

In addition to his matchless gifts as a singer, Santley possessed the most genial and warm-hearted character which won him hosts of friends. He also enjoyed superabundant vitality, and was able to take the long walks in which he revelled up to within a short time of his death.

TIMBER IN THE MARITIME PROVINCE OF SIBERIA.

There are no exact data regarding the total area of forest land in the Maritime Province of Siberia, but according to the American Consul at Vladivostok, it has been estimated that there are 490,000,000 acres of forest land in the entire Priamur District, comprising the provinces of Transbaikal, Amur, Maritime, Kamchatka, and Sakhalin. Nor is there any exact information as to the stand of the forests. In the southern part of the Maritime Province the species are very much mixed, deciduous and coniferous trees growing one next the other. In the northern part, most of the trees are of coniferous species and grow in large dense forests.

The pulp-wood industry has not been developed and there are no pulp or paper mills in this territory. The forests around De Castries Bay could supply from 2,000,000 to 3,000,000 trees annually, while Imperial Harbour, with Vanina and Data Bay regions, could supply from 500,000 to 1,000,000 trees a year. The principal kinds of trees available for timber from the Maritime and tributary Provinces are:—Pine (*Pinus sylvestris*); cedar (*Pinus mandshurica*); larch (*Larix dahurica*); fir (*Abies sibirica*); spruce (*Picea obovata*); oak (*Quercus mongolica*); cork oak (*Quercus Suber*); ash (*Fraxinus mandshurica*); walnut (*Juglans mandshurica*); aspen (*Populus tremula*); birch (*Betula alba*); witch elm; goat willow (*Salix Caprea*); and yew (*Taxus baccata*).

There is practically only one harbour for the Amur district—Nikolaevsk—into which ships over 16 ft. draft cannot enter because of the bar at the mouth of the Amur River Before the sacking of Nikolaevsk a small amount of timber was floated down the Amur from Lake Kisi, about 150 miles from the mouth of the river. Crude Chinese methods are used. Large "rafting" is possible, however; and notwithstanding the short navigation season 3,000,000 to 5,000,000 logs could be rafted annually.

Along the coastal region of the Maritime Province, between Vladivostok and Nikolaevsk, timber can be shipped from De Castries Bay, Imperial Harbour, Turney Bay, Titukhe, Olga, Amur, and Ussuri Bays, the first two being especially good.

Timber from the Ussuri District has been sent by rail to Vladivostok and from the Sungari District by rail to Vladivostok and Harbin. However, very little timber work is being carried on at the present time.

WOOL INDUSTRY OF CHINA.

While wool is at present one of the chief exports of China, millions of pounds being sent abroad each year, the fact that the potentialities of the market are even greater than its present supply is emphasised by the United States Consulate at Shanghai, in a report on China's wool industry. Though many varieties of sheep's wool are produced, the wool generally is of poor quality because the Chinese have not adopted modern scientific methods of breeding and management. Mongolia and Manchuria offer wide fields for development of the wool industry and, while now sparsely populated, could be fully developed by taking advantage of the surplus labour in the other Provinces. Improvements in breeding and management have already been undertaken in Hunan and Manchuria and a cleaning factory established in Tientsin, has greatly increased the exports. Experiments have been conducted by the South Manchuria Railway Co., and a crossbreed between the Merino sheep imported from abroad and the native Mongolian sheep has resulted in a production of wool of twice the quality and quantity on individual sheep. Sheep's wool from Tibet, while of better quality than that from Mongolia or Manchuria, compares unfavourably in price because of high transportation charges.

Camel's wool is produced in Mongolia and Chinese Turkestan. Russia consumes most of the yield in the manufacture of sweaters and quilts, although the United States takes a certain amount for the manufacture of carpets.

Prior to the war the United States took the entire supply of goat's wool from China, but when the war broke out the Japanese became buyers and in 1918 took two-thirds of the entire output. Tientsin is the centre of goat's wool production in the northern province and Ningpo is the market for the Yangtze yield, which, however, is inconsiderable.

PRODUCTION OF GUM MYRRH IN THE RED SEA DISTRICT.

The production of gum myrrh in the Red Sea district, during the past season, has been unusually good, both in quality and in quantity. In spite of this, an excellent demand has forced the price up nearly to the level attained during the war.

The trees which yield gum myrrh grow wild in various portions of British Somaliland, particularly in the territory of Ogaden, which produces the best. Smaller quantities of gum myrrh are produced in Arabia, as well as in Abyssinia. About a year and a half ago, writes the United States Consul at Aden, experts in growing gums made their way into sections of Arabia, near Katabba, where most of the gum trees abound, and it is reported that they are greatly improving the yield of the gum trees.

The following table shows the trade of Aden in gum myrrh :—

Countries of origin and destination.	1913-14	1918-19	1919-20	1920-21
	Cwt.	Cwt.	Cwt.	Cwt.
Imports from—				
Somaliland	19,445	15,149	15,451	11,609
Arabia.........	2,811	7,043	3,409	5,507
Exports to—				
Egypt	10,287	9,919	6,575	6,633
India	4,241	2,208	11,094	1,884
United States	140	182	341	261
Elsewhere ...	5,914	1,400	3,141	2,794
Total	20,582	13,709	21,151	11,572

GENERAL NOTES.

Benjamin Ward Richardson Memorial Lecture.—Sir William Collins will deliver the Benjamin Ward Richardson Memorial Lecture at the Barnes Hall of the Royal Society of Medicine, on Thursday, October 12th, at 5 p.m. Admission to the meeting is free and cards may be obtained from the Rev. George Martin, St. John's Vicarage, Kilburn. The lecture is given under the auspices of the Model Abattoir Society, which was founded in 1886 by Sir Benjamin Richardson, with the object of abolishing the private slaughter-house system, and making compulsory the adoption of the most rapid and humane methods of slaughtering animals.

Portland Cement as a Fire Extinguisher.—A report from the Chief Officer of the Seneca Fire Brigade, U.S.A., draws attention to the remarkable efficiency of Portland cement in extinguishing fire In the course of a fire which started in a general store and extended to an adjacent timber yard, the use of cement, of which there was plenty at hand, was suggested, and it was employed partly by scattering the material dry over stacks of timber in immediate danger and immediately wetted by the fire brigade, and partly in the form of thin grout thrown upon blazing timber. The effects were prompt and astonishing, the spread of the fire being almost instantly checked. The flames from timber already burning began to abate and within 1½ hour the fire was extinguished The cement grout thrown upon the blazing wood is said to have had a threefold effect (1) It acted similarly to dry powder chemicals, reducing the fire quickly and more efficiently than chemical powder as it acted in spite of the fact that the fire was in open air. (2) It almost entirely stopped the flying of sparks and tinder. (3) It caked over the fire, smothering it and shutting out air, so that combustion could not take place. An interesting use of cement in the store building was in extinguishing the blaze from a 400-gallon tank of oil into which tinned goods had fallen and were constantly exploding, throwing blazing oil about the building. The flames were finally extinguished by throwing sacks of dry cement into the tank. The report states that by the employment of cement a fire was stopped that would otherwise have entirely destroyed the timber yard.

Olive Oil Production in Italy.—The production of olive oil in Italy averaged 1,884,000 hectolitres (49,771,000 gallons) a year for the 1909-1920 period, according to figures issued by the Italian Ministry of Agriculture. The maximum output in one year was 2,890,000 hectolitres (76,347,000 gallons) in 1918 and the minimum was 958,000 hectolitres (25,308,000 gallons) in 1912 These figures, points out the United States Consul at Leghorn, refer only to the product of the first and second pressings. The sulphur oil and washed oil are additional and amount to about 500,000 hectolitres (13,209,000 gallons) annually. The average yearly crop of olives for the 12-year period was 1,140,600 metric tons.

Journal of the Royal Society of Arts.

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FRIDAY, OCTOBER 6, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE MECHANICAL DESIGN OF SCIENTIFIC INSTRUMENTS.

By PROFESSOR ALAN F. C. POLLARD, A.M.I.E.E., F.Inst.P.

LECTURE II.—*Delivered February 27th*, 1922.

We have now seen that by suitable application of five degrees of constraint, we can simulate the turning and sliding pairs of mechanism in a surprisingly simple manner. We cannot do this, however, with the screw pair—the third and most complicated pair of the three unique lower pairs of mechanism. The screw pair is a degree of constraint of the most general character and cannot be produced by constraining one point of the body to a curve surface.

For it consists in preventing one line of the body from longitudinal motion, unless accompanied by rotation round this line in fixed proportion to the longitudinal translation, leaving every other motion free.

The other free motions are two rotations about axes perpendicular to this line and two translations perpendicular to the same line. That is four degrees of freedom which, with the degree of freedom to screw and the one degree of constraint, make up the six elements.

The screw pair is possibly the most remarkable of all the ingenious mechanical inventions of man, and it is the most troublesome to manufacture. The Whitworth thread, for example, has seven elements, error on any one of which may be sufficient to cause a gauge to reject work which ought to pass or *vice versa*. These seven elements are

1. The full diameter or the overall diameter of the screw.
2. The Core diameter or the diameter at the root of the thread.
3. The Effective diameter.
4. Pitch.
5. Angle.
6. Radius at crest.
7. Radius at root.

An immense amount of work was done during the war on the production of the screw pair. But in spite of the ingenious methods which have been introduced for its accurate production and the delicate means which have been devised for checking the various errors to which it is liable, it is impossible to manufacture the screw pair with the same degree of precision as the turning and sliding pairs.

During the war many thousands of a certain gun clinometer* were required. An important part of this clinometer consisted of a double threaded screw about 5 inches long and 0·1 inch pitch, and a nut which was required to move from end to end of the screw without any variation of fit. The specification for its manufacture was exacting to a degree.

The nut as specified by the authorities, was fitted with three plungers P, Fig. 13, pressed against the screw spindle by three springs S, which were supposed to take up variations of fit and shake. This unsound design was doomed to failure, and after short use in the field, the nut worked loose.

A satisfactory nut was designed by the Cambridge and Paul Instrument Co.

There are 4 degrees of freedom; there must, therefore, be 4 parts of the nut upon which the screw spindle can bear.

These four parts are shown in part section in the figure and the single plunger P is the source of the pressure to ensure contact upon the 4 surfaces.

Since there must necessarily be generous allowances between a screw and its nut for the purposes of manufacture, there must be back lash.

*Trans. Optical Soc. Vol. xxii., p. 49.

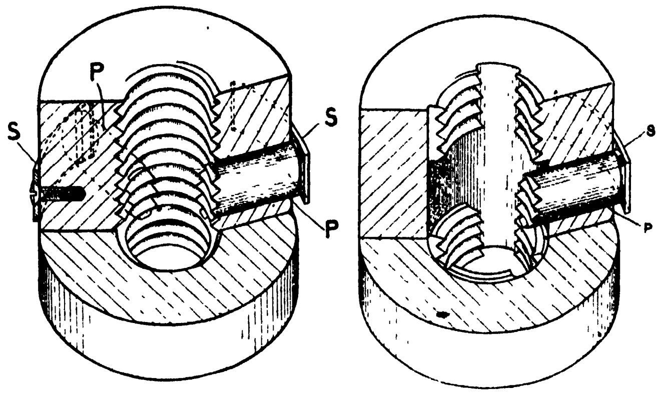

FIG. 13.

This back lash is a troublesome and undesirable evil and generally speaking in measuring instruments in which the screw is used as one of the metric elements, it must be overcome, or its range must be capable of exact measurement.

The back lash can be eliminated by keeping the screw and its nut in contact with the helical surface of the thread by pressure applied in the line of the axis.

This was done most simply and effectively by Sir Joseph Whitworth* in the design of his famous Millionth measuring machine, which is the forerunner to all modern measuring machines.

Thus by tightening these screws, the square thread on the screw spindle can be pinched to any extent desirable and all back lash removed.

The tangent screw engaging with the worm wheel H of the metric screw spindle is also made in two halves, upon the same principle as the divided nut and is made to press both sides of the teeth of the screw wheel, just as the nut is adjusted to press both sides of the square thread. Sir Joseph Whitworth stated that he sometimes found the back lash to lie within two-millionths of an inch, with this arrangement.

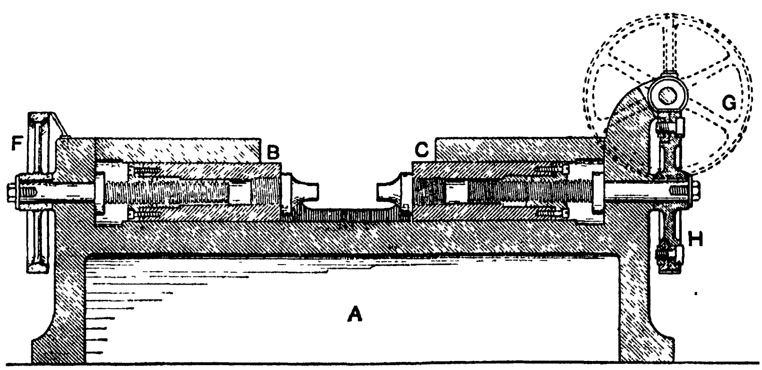

FIG. 14.

The nuts with which the carefully made square threaded metric screws engage are each split into two halves, as shown in Fig. 14. One half is forced into one end of the sliding block B or C, which carries the measuring anvil at its other end, and the other half of the nut is prevented from turning and is pressed inwards by four screws in the sliding block, two of which are shown in the section.

A modification of Sir Joseph Whitworth's design is one in which the secondary nut is prevented from turning and is pressed away from the primary nut by an intervening spring. Since the two nuts are upon the same screw the distance between them remains constant during rotation of the screw spindle and thus the axial pressure distributed over the threads of the spindle and its nut does not vary. This arrangement was used by Kelvin in the micrometer screws of his electrometers.

*The Whitworth Measuring Machine by T. M. Goodeve and C. P. B. Shelley. 1877.

In delicate measuring instruments this constancy of pressure is necessary.

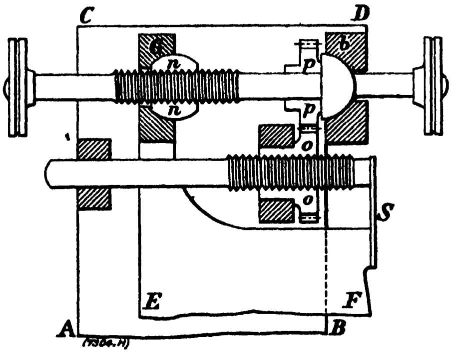

FIG. 15.

In a device invented by Grubb in 1886, for the declination slow motion of telescopes, shown in section Fig. 15, A, B, C, D is a portion of the arms attached to telescope or cradle, and E, F, G is the clamp arm. The screw has a bearing *b* with spherical seating on the telescope arms and its spherical nut *n* bears in the bearing G of the clamp arm. A short stiff spring S is attached to this clamp arm, bearing not directly against any part of the other arm, but against the end of a second screw of the same pitch as the main screw, the nut of which is a pinion *oo* engaging with a similar pinion *pp* keyed to the main screw. The point of this second screw, therefore, advances as much in one direction as the frame A, B, C, D is carried in the other, when the milled head is turned and consequently the point of the screw does not sensibly vary in its position with respect to the clamp arm E, F, G. In this way a short stiff spring brings a constant pressure to bear between the screw and its nut.

A common way of eliminating back lash between screw spindle and nut is to split the nut longitudinally so that it can be clamped with suitable pressure upon the screw. Such an arrangement is found in the fine adjustment of the large Zeiss photomicrographic microscope stand which has been pronounced by some people to be so perfect in its action.

This method, however, must be used with considerable caution, for the roots and crests of the components may be forced into contact unless the thread is very carefully made. If contact between the roots and crests takes place to the exclusion of contact between the helical surfaces of the thread, rapid wear takes place and erratic relative motion of the screw and its nut soon develops.

The nut of the screw spindle of the Fabry and Perot interferometers is split and clamped. But the thread has been specially designed.

The crests and roots are made to clear one another, and when the nut is clamped the pressure is taken by the helical surfaces of the threads only.

If the standard Whitworth form of thread is used the clearance of roots and crests, it has been found, gives too small a bearing on the helical surface of the thread. Consequently the thread has been re-designed and an angle of 47° has been given to the thread instead of the standard 55° angle of Whitworth. In this way sufficient bearing surface is ensured.

The fine adjustments of microscopes are in the majority of instruments either screw or lever devices, designed to magnify the movement of the optical system at the milled head of the adjustment.

The function of the fine adjustment in high class research instruments should be chiefly metric and should be used as sparingly as possible merely for the purpose of focussing.

It is essential then, in this case, that the velocity ratio of the mechanism should be constant, that is to say, no matter what the position of the milled head, a unit turn of it should move the optical system through the same distance.

Generally speaking, this is not possible with a system of levers, and, further, they are liable to rapid wear, and to develop variable contact, which alters their ratio and introduces unsuspected error.

There is a form of screw mechanism peculiarly adaptable to the fine adjustment of microscopes which I wish to bring before your notice. It is the so called Campbell differential screw, said to have been originally invented by White for other purposes.

Two screws, S and T, of different pitches, are cut on the same spindle. (See Fig. 16.) The first screw engages with a nut fixed to the limb of the instrument, while the second screw engages with a nut H fixed to the tube carrying the optical system. A single rotation of the milled head D advances the screw and carries the tube with it through a distance equal to its pitch, but during this rotation, the second screw causes its nut and hence the tube, to advance in the opposite direction, through a distance equal to *its* pitch.

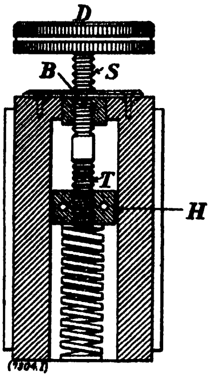

FIG. 16.

So that, during one rotation of the milled head, the tube advances a distance equal to the difference of the pitches of the two screws, whilst the milled head itself advances a distance equal to the pitch of the first screw.

Thus, if the two screws have 30 and 31 threads to the inch respectively, one turn of the milled head advances the optical system through 1/930 of an inch, whilst the milled head itself moves through 1/30″ axially. Thus a delicate and minute movement is accurately given to the tube by means of two screws of coarse pitch and robust construction. Further, if a vertical scale is placed against the edge of the milled head, its unit representing one turn of the head, is 1/30″ long.

Thus, 1/30″ on the scale represents a movement of 1/930″ of the optical system.

If the spindle has 20 and 25 threads cut upon it, then the movement of the tube corresponding to unit turn of milled head is 1/100″. Almost any desired velocity ratio can be obtained, and, moreover, the device is a strictly metric one, for the velocity ratio is constant throughout the whole working range.

Why this almost perfect adjustment for microscopes has gone out of fashion I am at a loss to understand.

As a rule, the screw spindle of these Campbell differential movements is far too small in diameter, and certainly should not be less than that of the screw spindle of the ordinary shop micrometer to withstand wear satisfactorily. This may account for the unpopularity of this fine adjustment.

(The lecturer showed a microscope kindly lent and made by Messrs. Swift, with this differential screw fine adjustment, which was 20 years old, and at the end of the lecture the perfect focussing of a 1/12″ oil immersion was demonstrated.)

Frequently, the success of measuring instruments depends upon the manner in which the nut or screw spindle is connected to the moving piece of the instrument, or the manner in which the screw spindle is restrained from end long motion.

It is essential that no indeterminate strains should be set up between the screw and its nuts, or that the screw spindle should not oscillate axially during its rotation.

An excellent design obviating possible strain between screw and nut, is shown in the feed screw mechanism of the rocking microtome of the Cambridge and Paul Instrument Co. The movement of this nut determines the thickness of the section cut, and this must be constant throughout the range of working.

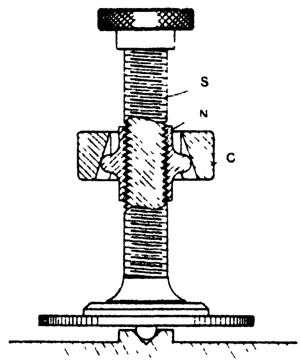

FIG. 17.

The screw, S, Fig. 17, works in a nut N, on which the lever rests at its ring-shaped end, shown in section at C. Two V grooves are formed in the ring shaped end C and the nut has wings which engage with those grooves. It is thus prevented from turning and yet can take up a position of repose on the screw spindle.

In other cases the end of the screw spindle bears against the moving piece and the axial movement of the screw spindle has to be accurately communicated to the moving piece.

A simple arrangement to ensure contact between the end of the screw and the piece to be moved is to close the kinematic chain by a constant force closure in the form of a "C" spring as shown in Fig. 18.

This simple and effective arrangement is due to Sir Horace Darwin, but though constant pressure is brought to bear

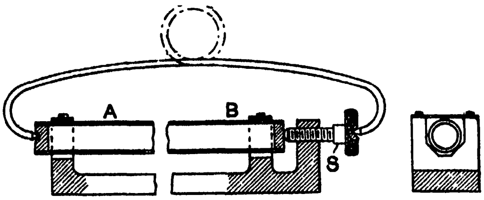

FIG. 18.

axially between the two pieces and consequently they cannot be subjected to lateral strains, it does not do away with back lash.

If, however, the end of the screw is not precisely a surface of revolution about the axis of the screw spindle, its point of contact will describe a small circle on the bearing surface of the moving piece, and if this surface is not exactly square to the axis a periodic error will develop between the screw and the piece. In addition to this, unnecessary strain may be set up between the pieces.

The manner in which these defects may be overcome is shown in the mechanism of the Cambridge and Paul Instrument Co.'s reading microscope, and also in the substage screw adjustment of the Keith Lucas microscope with geometrical slides, already referred to.

In the reading microscope, a section of arrangement it is necessary, of course, that the rod shall always be pressed against the end of the micrometer screw with a constant pressure. The long spring S attached to the frame at the right hand end and to the end of the tube on the left, performs the double duty of maintaining the necessary pressure against the micrometer screw and eliminating back lash between the latter and its nut, and is sufficiently long to maintain a fairly constant pressure over the working distance of the screw. (*The lecturer here showed the instrument.*)

Such an arrangement as this, however, would be unsatisfactory for such an instrument as the Fabry and Perot interferometer, where accurate movements within less than 1/10th of a wave length of light, *i.e.*, within a fraction of 1/20,000 mm. on the average, are necessary.

In this instrument the arrangement of coacting parts to obviate the possible oscillation of the screw spindle is very beautiful. The thrust of the spindle is taken up by a quartz plate, which bears against a small and highly polished area on the end of the spindle, which is produced before the spindle is unchucked from the lathe in which it is made. The area is thus dead square to the axis of revolution.

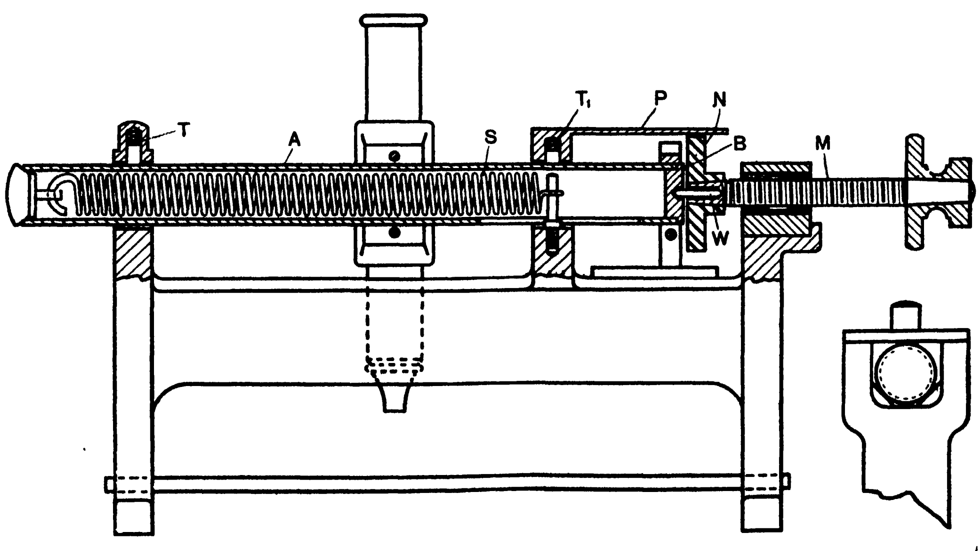

FIG. 19.

which is shown in Fig. 19, the micrometer screw M is connected to the hollow rod A (to which the travelling microscope is clamped) by the small steel link or rod W, the pointed ends of which are seated in countersinks in the two pieces. With this

If now the point of contact of the spindle and quartz plate be observed through the latter, interference bands will be seen. If the quartz plate is not dead square to the axis of revolution these bands will shift during a turn of the spindle.

The quartz plate can then be adjusted until no such shift takes place.

So that in this way the point where the geometric axis of revolution of the screw spindle cuts the plane of the quartz plate can actually be seen and perfect adjustment secured. (*The lecturer here showed the instrument.*)

In all gearing in which teeth engage with one another by sliding and rolling contact back lash is very troublesome when accuracy is required.

A very ingenious arrangement for overcoming this difficulty in the case of bevel gears is shown in an excellently designed mass production refractometer of Messrs. Bellingham and Stanley, patented by Mr. W. Taylor.

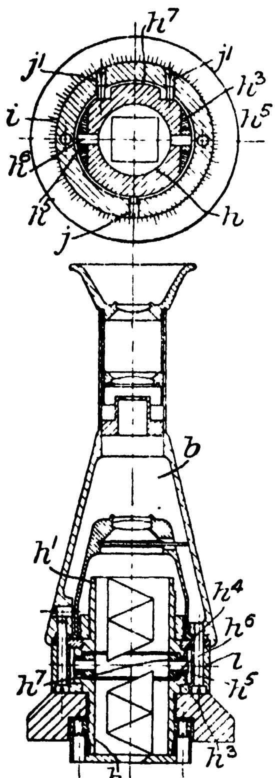

Fig. 20.

Vertical and horizontal sections through the parts which are of interest, are shown in Fig. 20.

It is necessary that the two compound prisms used for the compensation and measurement of dispersion, and housed in the two sleeves h^1 h, be capable of measured rotation in opposite directions without loss of motion in either sense. To secure the opposite rotations the inner ends of the sleeves are formed as crown gears h_3 and h_4, which are engaged and connected by two bevel pinions h_5 rotating freely on studs h_6 fixed on the opposite sides of a ring h_7. To eliminate backlash this ring is permitted a small amount of play transverse to the optic axis of the tube and can be clamped in such a position by the screws j^1 j^1 and j, that the bevel pinions bear equally upon the crown gears.

Another device to obviate back lash between two pieces, which I cannot refrain from describing, is the ingenious one of Mr. William Taylor to prevent back lash between the index plate of a dividing head and its face plate. The index plate is centred by fitting closely and squarely up to a shoulder on the plain cylindrical extension or hub of the dividing head face plate, to which it is secured by the taper pins projecting from the face of a split collar.

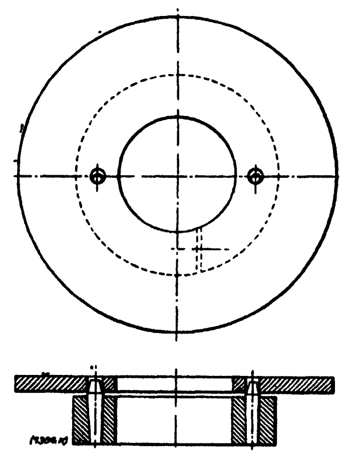

Fig. 21.

These pins engage in holes in the index plate. The two holes in the index plate are on one straight line through the centre of the plate, but the pins in the collar are placed to engage the holes of the plate, both on one side towards the slit in the collar, as shown in Fig. 21.

In use, the index plate is pushed on to the hub and is followed and pressed up to the shoulder by the split collar. The pins engaging in the holes force the index plate into contact with the hub and thus prevent all back lash.

Tightening the collar then further tends to jam the index plate. It will be observed that this is an essentially manufacturing

proposition for not only is the alignment of holes and pins avoided, which alignment would be very troublesome in manufacture, but the back lash unavoidably attendant upon such alignment is entirely got rid of.

The design is geometrical for it will be seen that the index plate has three surfaces of constraint to prevent its movement relative to the face plate in its own plane, one on each pin and one on the hub.

Before leaving the screw pair the troublesome crossing of screw threads when engaging two screw members of large diameter and small pitch and means of avoiding the trouble, may be mentioned.

If one member is provided with a cylindrical "pilot" by turning away a few threads to the root or core diameter the co-axial relation of the two parts is secured by the crests of one member engaging with the "pilot" of the other before the threads engage.

Another way, due to Mr. William Taylor, is to mill away the tapering portion at the commencemnet of the thread in both members. Then by marking on the flanges the part of the circumference where the abrupt threads commence no difficulty will be found in trying to engage them.

If the threads are milled, the abrupt thread may be produced by a suitable cutter without adding to the cost of the operation.

This abrupt thread is specially useful for the mounts of lenses in optical instruments. (*The lecturer here showed samples of lens mounts.*)

In cases, however, where several lens mounts are assembled in a tube and require to be changed frequently for cleaning or for the purpose of quickly changing the optical system, a most ingenious method has been invented by Mr. William Taylor, which reduces the cost of production.

The lens is mounted in a short cylindrical cell the outside diameter of which is slightly less than the outside diameter of the tube it has to fit.

A little more than half this circumference is milled away to a radius equal to that of the inside of the tube.

The tube itself has a slot milled across it nearly to the diametral plane of the tube, and of a width equal to the height of the mount. The mount will then snap into the tube.

These are seen in Fig. 22, where the microscope tube of a "Talyden" is shown with the lense mounts assembled. and also just engaging with the milled slots in the tube ready to snap into place.

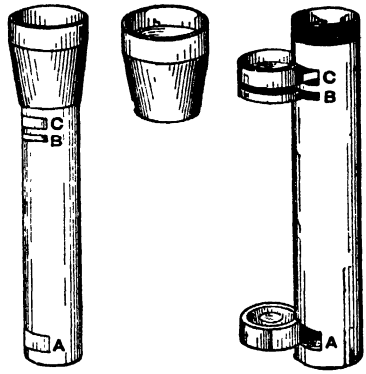

FIG. 22.

Let us now return to the geometrical slide. We have seen that by causing the part of an instrument to have contact at five points on five suitably chosen surfaces, we not only constrain it to move with one degree of freedom, but we allow it to take up a position of repose, and none of its parts are subjected to unnecessary strain.

If, therefore, we merely require that the body shall have no rotations about the two horizontal axes, and be constrained in one of its translations only, we can remove two more surfaces and allow the body to rest on three. Thus we see that a rigid body will rest by three points on an uneven fixed surface in a state of repose, without unnecessary strain. If, however, the body is heavy, and no longer rigid, it will bend between the points of support in virtue of its own weight, and this is the necessary and unavoidable strain to which it will be subjected.

This bending for a given elastic body will be greater the greater the distance between the supports, and the question at once arises whether it is possible to extend the principle of a three point support to several points distributed over the under surface of the body so as to reduce the flexure between the points of support produced by gravity. It is at once evident that, provided we do not fix any of the subsidiary points of support, and limit the fixed surfaces to three, we shall leave the body free to take up its position of repose.

Thus, if we support the body at nine points by means of three frameworks, each with three bearings and each framework at one point on each of three fixed

bearings, the body will rest in a state of repose.

This process can be pushed to any extent, and the body can be supported at any number of points in a state of repose.

It will be instructive to examine for a moment the way in which Lord Rosse* supported the six foot speculum of his giant telescope which weighed over three tons. He says:—

"The cast iron carriage carries three ball and socket joints, directly under the centre of gravity of three equal sectors, into which the speculum may be supposed to be divided (as shown at A, B and C, Fig. 23.) The centre of the ball is in the

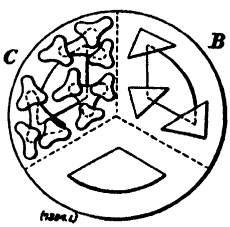

FIG. 23.

centre of gravity of the triangle (shown isolated in Sector A), not merely as respects its plane, but thickness also. These three triangles which we call primary, carry at their angles, by ball and socket joints, nine secondary triangles (shown in Sector B), supported at their respective centres of gravity; and they, in a similar way, carry twenty-seven tertiary triangles (shown in sector C) each carrying three gun metal balls of 1½ inch diameter—in all, eighty-one balls, which support twenty-seven equal portions of the speculum. Between the balls and the speculum, twenty-seven thin brass plates are interposed, attached to the speculum by pitched cloth, not so much with a view of giving support between the balls, which would probably be quite unnecessary, but to make a smooth surface for the balls to roll upon without grinding the back of the speculum true."

The iron polishing tool weighing over one ton, is suspended by thirty-six points in a manner similar to the support of the mirror, and is shown suspended in Fig. 24.

"As soon as the tool is prepared, the gimbals are removed; and it is then managed by the shackle in the centre.

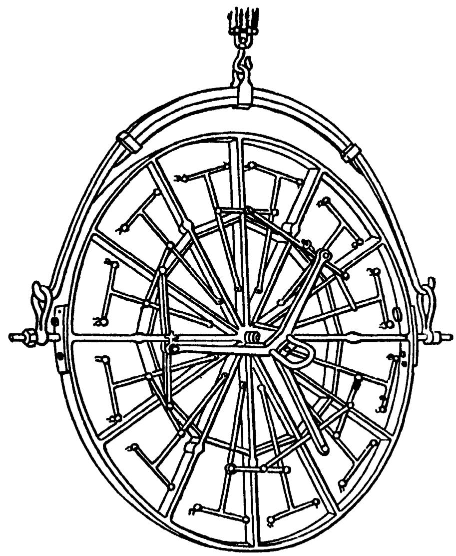

FIG. 24.

The shackle carries a triangle with a lever at each angle. Each lever carries similarly two levers, connected at their extremities with T shaped levers, which carry the tool by thirty-six points. The chain through which the counterpoise acts during the progress of grinding and polishing, is hooked to the shackle and the strain is thus distributed so equally that there is no sensible distortion."

This sytem of vertical support to the speculum of Lord Rosse is in principle the same as that applied by Grubb in 1834 to a 15 inch speculum constructed for the Armagh Observatory.

If we turn to Grubb's arrangement of

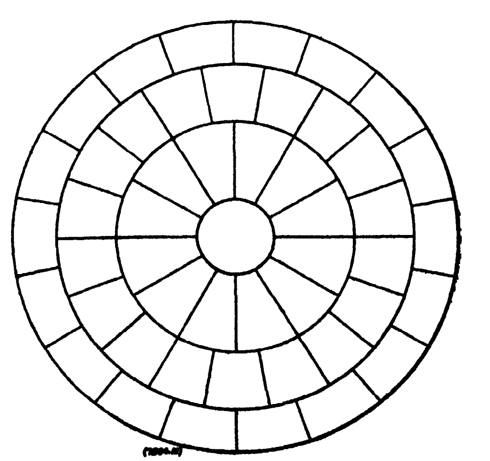

FIG. 25.

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* Roy. Soc. Phil. Trans. Vol. 151. 1861. p. 681.

the points of support for the four foot speculum of the Great Melbourne Telescope*, we shall find that it is similar to Lord Rosse's except that Grubb managed to pack the levers into a smaller space vertically.

The speculum is supposed to be divided into 48 portions of equal weight. See Fig. 25.

These portions are supported by the 48 points of 12 triangular levers, and six straight levers, shown at C, Fig. 26. The centres of these 18 tertiary levers are supported by six triangular secondary levers, two of which are shown at B.

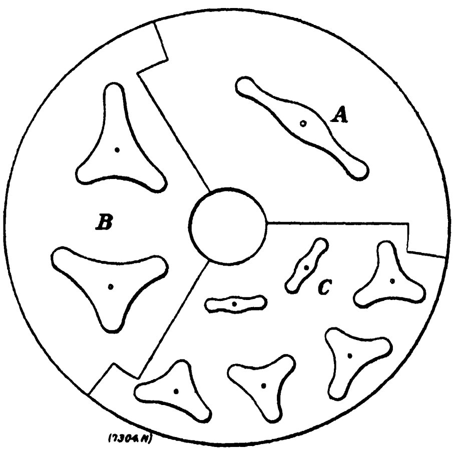

FIG. 26.

The centres of these six secondary levers are supported by the three primary straight levers, one of which is shown at A. Finally, the centres of these three primary levers are supported on three fixed surfaces of the frame.

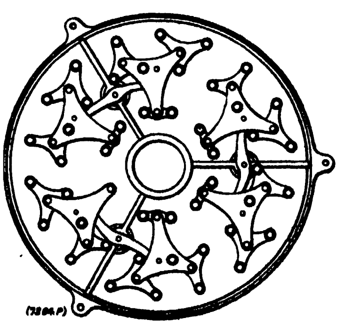

FIG. 27.

Fig. 27 shows the final arrangement of all the levers on the under side of the great mirror.

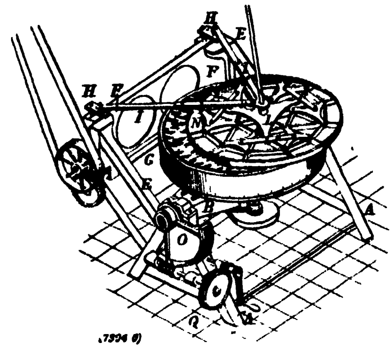

FIG 28.

Fig. 28 shows the polishing machine with the mirror and polishing tool in position, and it will be observed that the support of the tool to prevent flexure is similar to that adopted by Rosse.

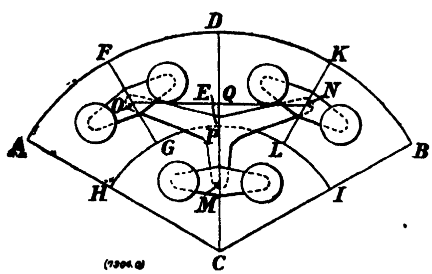

FIG. 29.

Figure 29 shows Lassell's* method of supporting large specula. The sector of 120° is divided up into six equal areas, and thus the whole speculum into 18 equal portions.

The circles represent discs of brass bearing against the back, the centres of which coincide with the centre mass of the elementary areas into which the speculum is supposed to be divided. Pairs are connected by short levers at each end of which is a hole loosely fitting pins projecting from the discs. The under surface of the discs are small segments of spheres. The centres of these levers are again supported by the ends of a triangular lever MNO, in the same manner as the discs are supported by the first three levers.

Finally, the point P of this lever is supported on a screw or stud fixed in the end plate of the telescope tube. The point

*_Roy. Soc. Phil. Trans._ Vol. 159, 1869, p. 127.

*_B.A. Report_, 1850, Edinburgh, p. 181.

P is the centroid of the loads at MNO, and, therefore, PM=2 PQ. Thus, the mirror is ultimately supported on three points.

Lassell finds that the mirror is distorted with change of temperature, and rightly assigns this defect to differential expansion between the iron of the levers and the speculum metal and to the fixation of the various points of support. This defect, he states, he has to some extent removed by making the surfaces of contact of the discs as smooth as possible. To remove the defect entirely he proposes to make the metal of the levers of an alloy described by Lord Rosse, which has sensibly the same expansion as the speculum metal itself.

In the 72″ reflecting telescope at Observatory Hill, Victoria, Columbia, of which the mounting is made by the Warner and Swasey Co., of Cleveland, Ohio, the mirror has an aperture of 72″ with a focal length of 30 feet and is used either with a Newtonian flat or with a Cassegrain mirror.

This huge mirror is so thick that it is only necessary to support it on nine counterbalanced pads arranged in groups of three, and it is stated that it nowhere departs from the correct parabolic figure by more than an eighth of a wave length of light.

In many instruments there is a moving part which acts as an indicator, and the position or motion of the indicator allows us to deduce some conclusions with respect to the force that acts upon it. This force will be the quantity we desire to measure, but friction is always present between the co-acting parts and reduces the accuracy of our observations.

If the magnitude and direction of the resisting force of friction were always known, it would be of no consequence.

But the magnitude of friction is liable to sudden alterations owing to causes which we can often neither suspect nor detect, so that the only way in which we can make any approach to accuracy is by diminishing as much as possible the effect of friction.

Nevertheless, in sensitive instruments, however much it may be diminished friction introduces an error which we shall discuss later on.

Whenever there is sliding or rolling contact there is friction, but if it is possible to make the extent of the sliding or rolling small compared with the movement of the indicating part, we may reduce the effect of friction to a very small part of the whole effect.

An example of this which appears to have been forgotten is Joule's method of mounting the needle of a dip circle.* The axis of the needle, instead of rolling on agate planes, is slung on two filaments of silk, the ends of the filaments being attached to the arms of a delicate balance.

In order that the needle may be in neutral equilibrium as it rolls upon the filaments, its centre of mass must neither rise nor fall. To secure this condition, it is only necessary that the arms of the balance are equal and the filaments are at right angles to them.

Like friction, the elastic force of torsion of a filament, though much more regular, is liable to alterations arising from known, as well as unknown, causes, and depending largely upon its previous history.

Hence it is sometimes better to employ a mode of suspension in which the force of restitution depends upon the weight of the suspended parts rather than upon the elastic torsion.

Such a suspension is the well-known bifilar suspension, invented by Gauss and Weber for their magnetic instruments, and afterwards used by Baily in his experiments on the attraction of masses. The suspended body is in equilibrium, and its centre of mass is in the lowest position when the two filaments are in the same vertical plane. When the body is turned about a vertical axis, its centre of mass is raised since the filaments remain constant in length, but move out of the vertical plane. Gravity, therefore, brings the body back to zero position, and this force is very regular in its action, and more reliable than the elastic force of torsion.

In turning pairs the friction may be reduced by reducing the size of the axle and by supporting it on friction wheels or by reducing the area of contact to that of a point bearing in a pivot cap or jewel, or by reducing the area of contact by means of hardened balls placed between the axle and its bearing.

In cases where the movement of rotation is small, the friction can be still further reduced by the use of knife edges.

In balances and other lever systems the bearing of the lever is in the form of a knife edge which rests on a plane.

No matter how carefully a knife edge is made, its physical edge is in reality cylindrical

* *Electricity and Magnetism, by Clerk Maxwell. 3rd ed. Vol. II., p. 125.*

so that the friction is due to the rolling of a cylinder of small radius upon a plane.

Thus in all measuring instruments which make use of lever systems with knife edges, and are dependent for their accuracy upon the ratios of the arms of the levers, besides the error due to friction, there is error due to the shifting of the point of contact as rolling proceeds, though frequently this error is so small that it does not sensibly alter the ratio of the lever arms In delicate mechanisms, it introduces a form of variance which we shall discuss later. In addition to this, the radius of the rolling cylindrical edge increases with wear, which is a very undesirable feature. Nevertheless, knife edges are the best means at our disposal in our attempts to secure small rotations about a definite axis with minimum friction, when the load is not excessive.

Since a knife edge can slip about on its supporting plane, and rotate about the vertical as well as about its edge, it has four degrees of freedom. It requires, therefore, only two surfaces of constraint and can in some cases be replaced by the contact of two steel balls rigidly connected together bearing on a plane. Such a knife edge is useful when the radius of the rolling edge is required to be accurately known. In some devices, however, the radius of the rolling edge is required to be known and to be so small that it cannot be constructed.

There is a very beautiful little instrument —The Talymin—which illustrates this remark. The design of this instrument is by Mr. William Taylor, and it is constructed by Messrs. Taylor, Taylor and Hobson.

The instrument is a comparator and is used for the purpose of checking the dimensions of manufactured parts acurately and quickly to the 1/10,000″.

Consider a cylinder of small radius, r Fig. 30, which has rolled a distance x on a plane. If a pointer is attached to the cylinder, the pointer of length l will move over a scale distance c.

Consequently since $r/x = l/c$,

If $x = .0001''$, $l = 4''$ and $c = .04''$. $r = .01''$.

It would be quite impossible to make a roller of .02″ in diameter.

This difficulty has been overcome by Mr. Taylor in this way.

Two coaxial cylinders of radii r_1 and r_2 are turned out of the same rod.

Round them are wrapped two bands B_1 and B_2 respectively secured to the cylindrical portions of radii r_1 and r_2. The

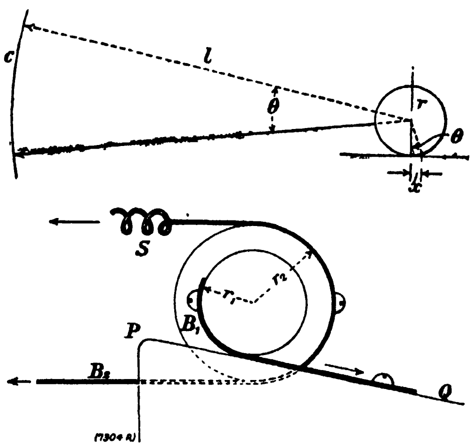

FIG. 30.

band B_2 is connected to the plunger at the end of which is the measuring anvil. This plunger is pulled by a spring in the direction of the arrow and also in the opposite direction by the weaker spring S.

The smaller cylinder rolls upon the plane PQ to which the band B_1 is secured.

If the cylinders roll through an angle φ indicated by the pointer attached to them, the band B_2 moves through a distance $r_2\varphi$, but in so doing the cylinder r_1 rolls on the plane and so carries the band B_2 through a distance $r_1\varphi$ in the opposite direction.

So that the total movement of the band is $(r_2 - r_1)\varphi$.

Now the difference $r_2 - r_1$ can be made as small as one pleases and thus a minute movement of the band is indicated by a large movement of the pointer.

In the actual instrument the plane PQ is inclined so that the tension of the bands keeps the roller in contact with it and this modification introduces a correction in the simple formula which is of no consequence for it can be definitely calculated.

The Air Ministry are having considerable trouble with their altimeters, which are nothing but aneroids that measure the altitude by decrease of the pressure of the atmosphere. In these aneroids the pressure is indicated by the movements of a diaphragm which will not recover quickly when the aeroplane is rapidly descending. This is due to a certain elastic drift caused by overstrain of the diaphragm, which might be considerably reduced by making it stiffer and eliminating the corrugations which are the seat of overstrain with correspondingly smaller movement for a given variation of pressure. But this movement of the

diaphragm would be so small that the present arrangement of the coacting parts in the instrument would not give an open scale easily read.

The application of Mr. Taylor's invention to this instrument might get over all the difficulties which at present make it an unreliable instrument.

In some applications of the knife edge it is necessary to impose upon it two more degrees of constraint, so that it may have but two degrees of freedom left, *i.e.*, a rotation about its edge and a motion of translation in the direction of its edge.

The latter freedom can be limited to small excursions by suitable stops, which during rotation of the edge are held free of it.

The knife edge must then bear against four surfaces.

A geometrical design of such a knife edge is shown in Fig. 31, and is incorporated in the rocking microtome of the Cambridge and Paul Instrument Co.

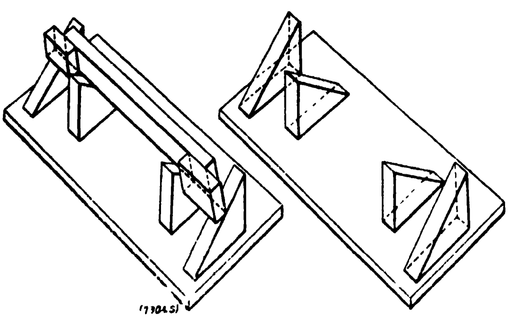

Fig. 31.

The knife edge is formed by three prisms of rectangular section connected together so that the three lower and inner edges are contiguous. The single edge thus formed bears on four planes sloping at 45° to the horizontal, as shown in the figure — the portion of it which is part of the central prism bears on the two inner sloping planes and the portion formed by the two outer prisms bears on the outer planes sloping at 90° to the former. Thus the compound prismatic piece turns about a single 90° and, therefore, robust edge, which is seated in what is virtually a 90° "V" groove.

In this design it is evident that if the knife edge bends owing to excess of load, the two outermost edges will leave their planes and the geometrical relations will be sacrificed.

This deficiency is ingeniously overcome in the arrangement shown in Fig. 32.

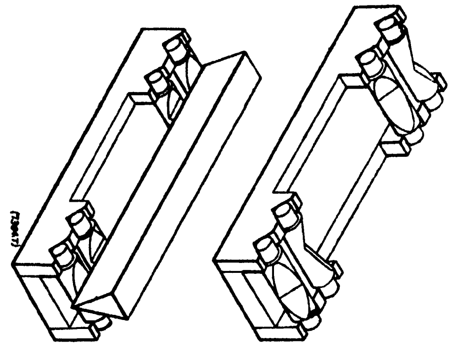

Fig. 32.

Here the knife bearing planes are capable of rotation about axes perpendicular to the direction of the knife edge. So that when the knife edge bends the planes rotate and maintain line contact with the edge. Such an arrangement should be of value in heavy weight measuring machines, such as locomotive beams.

These two beautiful geometrical designs are due to Sir Horace Darwin.*

So far we have discussed in detail various devices which will reduce the aberrations in the geometrical relations of the coacting parts of an instrument to a minimum. It now remains for us to see how the various imperfections due to friction, back lash and want of true elasticity, etc., affect the indications of the instrument in relation to the measured quantity.

**Scientific Instruments, their Design and Use in Aeronautics, by Horace Darwin, M.A., F.R.S. Aeronautical Journal, July,* 1913.

NOTES ON BOOKS.

Argonauts of the Western Pacific. By Bronislaw Malinowski, Ph.D. (Cracow), D.Sc. (London). With a Preface by Sir James George Frazer, F.B.A., F.R.S. London: George Routledge & Sons, Ltd. 21*s*. net.

This volume forms part of the excellent series of monographs by writers connected with the London School of Economics and Political Science, and gives an extraordinarily interesting account of the social life and institutions of a group of islands of which the very name is hardly known to the ordinary reader. In 1914 the author was awarded the Robert Mond Travelling Scholarship, which, with some other assistance, enabled him to devote the period 1914-20 to ethnographical research. After spending six months among the natives of Mailu in New Guinea, he pro-

ceeded to the Trobriand Islands, to the east of New Guinea, where he spent about two years, living amongst the inhabitants as one of themselves, conversing with them in their own tongue, and gaining a remarkable insight into their institutions and methods of thought. The present volume gives the results of his observations, and, illustrated as it is by numerous photographs and maps, it is a remarkable contribution to the study of primitive sociology.

Perhaps the most interesting and novel feature in the book is Dr. Malinowski's account of the institution known as *Kula*. This is a form of exchange of extensive, inter-tribal character, carried on by communities inhabiting a wide ring of islands, which form a closed circuit. "Along this route articles of two kinds, and these two kinds only, are constantly travelling in opposite directions. In the direction of the hands of a clock moves constantly one of these kinds—long necklaces of red shell. In the opposite direction moves the other kind—bracelets of white shell. Each of these articles, as it travels in its own direction on the closed circuit, meets on its way articles of the other class, and is constantly being exchanged for them. Every movement of the Kula articles, every detail of the transactions is fixed and regulated by a set of traditional rules and conventions, and some acts of the Kula are accompanied by an elaborate magical ritual and public ceremonies."

In every island within the circuit a certain number of men take part in the Kula. They receive the goods, hold them for a short time and then exchange them. Associated with this ceremonial the natives carry on ordinary trade, bartering from one island to another a great number of goods, often unprocurable in the district into which they are imported, and indispensable there. Thus the Kula is an extremely big and important institution: it involves the building of a large number of sea-going canoes, it welds together a large number of tribes, "and it embraces a vast complex of activities, interconnected, and playing into one another, so as to form one organic whole."

Dr. Malinowski's full account of this remarkable institution throws a fresh light on the old Jeremy Bentham conception of Primitive Economic Man. Kula, as Sir James Frazer remarks, "is not based on a simple calculation of utility, of profit and loss, but it satisfies emotional and æsthetic needs of a higher order than mere gratification of animal wants." It would indeed seem to be Primitive Economic Man's substitute for the circulating department of the Victoria and Albert Museum! "The trade in useful objects, which forms part of the Kula system," Sir James continues, "is in the minds of the natives entirely subordinate in importance to the exchange of other objects, which serve no utilitarian purpose whatever. In its combination of commercial enterprise, social organisation, mythical background, and magical ritual, to say nothing of the wide geographical range of its operations, this singular institution appears to have no exact parallel in the existing anthropological record; but its discoverer, Dr. Malinowski, may very well be right in surmising that it is probably a type of institutions of which analogous, if not precisely similar, instances will hereafter be brought to light by further research among savage and barbarous peoples."

INTERNATIONAL AIR CONGRESS, LONDON, 1923.

Following on the Congrès International de la Navigation Aérienne held in Paris in November, 1921, it is proposed to hold a similar congress in London towards the end of June next year. Group Captain the Duke of York, has consented to become President of the General Council of the Congress, and Lord Weir of Eastwood, has accepted an invitation to become a Vice-President. A strong organising committee representative of all phases of British aeronautical activity, ncluding the Air Ministry, has been formed, with the Duke of Sutherland as Chairman.

The Congress will be open to all countries which are signatories of the International Air Convention, or are represented on the Fédération Aéronautique Internationale; individual invitations being issued through national committees in process of formation in each country. Membership will be divided into two classes: (a) Ordinary Members, and (*b*) Associate Members, comprising the families of ordinary members, at a subscription of £1 and 10/- respectively.

According to present arrangements the Congress will occupy one week during the last fortnight in June, 1923, the reading of papers alternating with visits to various aircraft factories and establishments. It is hoped that the Air Ministry will be able to arrange for the Royal Air Force Pageant to take place on the Saturday of the Congress week and that the Royal Aero Club may organise a race meeting on the Tuesday or Thursday. Monday, Wednesday and Friday will be devoted to the reading of papers, and discussions thereon, which will be divided into four or more main groups or sections holding simultaneous sessions in different rooms.

As the time available for the reading of papers will be limited, a "reading committee" is to be formed, though it is hoped to arrange that the official report of the Congress to be published later shall contain a wider selection of the papers sent in. An official reception will be held in the evening of the Monday of the Congress week and the proceedings will be closed by an official banquet on the Saturday.

It is important that the Congress should not be confused with the British Air Conference called each year by the Air Ministry. The latter is of a domestic nature dealing with aeronautical matters so far as the British Empire is concerned. The Congress, on the other hand, is essentially international in character and is intended to be one of a series to be held in various countries at which experts may meet to discuss the technical and scientific development of aeronautics in all its aspects.

MOTHER OF PEARL INDUSTRY IN BETHLEHEM.

Bethlehem, in Palestine, is the centre of a mother-of-pearl industry which supplies beads, rosaries, inlaid work, carvings, and miscellaneous ornaments to all parts of the world. This industry is one of the most important of the few that exist in the Holy Land.

Of the rosaries made in Bethlehem from mother-of-pearl beads, combined with silver or white-metal chains and wire, about one-third of the total product is exported to North and South America and the remainder goes principally to European countries of which, before the war, Austria and Germany received particularly large quantities. During the year 1913, writes the United States Consul at Jerusalem, there was invoiced at the American consulate in Jerusalem for shipment to the United States, $19,207 worth of Bethlehem mother-of-pearl rosaries of the first and second class qualities. For the calendar year 1920, the total value invoiced amounted to $31,846. Only shipments valued at $100 or more require consular invoices, and it is probable that during these two years there were as many rosaries and beads taken or sent to the United States in small quantities as were invoiced at the consulate

The long strings of beads known as necklaces are not so important in the export trade as are the rosaries. A great many necklaces are sold to tourists by local curio shops. Considerable quantities of tiny beads are made and sold in strings or bunches to be used for various trimming purposes. These beads are in demand by the Moslem women of northern Africa, particularly in the Algerian markets, which are supplied by French dealers where they are used as trimming for articles of clothing Beads of various sizes, usually in the round form, are made into small strings of "play" beads. A great many beads in this form are sold to Moslems and certain classes of Levantine Christians. Amber, glass, and other materials are used for these "play" beads, but the use of mother-of-pearl for the purpose is increasing.

The refuse, broken pieces, and butt ends of mother-of-pearl shells, used by button factories, supply most of the raw material used in the Bethlehem bead and rosary industry. For the larger carved pieces and other pieces requiring whole or nearly whole shells, the raw material is obtained directly from the Red Sea, India and Australia, but the imports of this class of raw material are not large.

The waste from the button factories is imported in quantities estimated at about 20 tons per month. Most of this waste is obtained from the United States, as a greater supply is available there than in other countries.

The silver and white metal fine chains and wire are a speciality of French manufacturers. The comparatively small quantity of muriatic acid used for polishing purposes is also obtained from France. The coarse files used are obtained second-hand in Europe and can be used and re-sharpened many times in Bethlehem. The total amount purchased in a year is insignificant.

TOWN PLANNING.

The third annual report of the Ministry of Health says that it is becoming increasingly recognised that the policy of town planning is not only one which will guard the future growth of towns against the inconveniences and the serious evils which have been the result of the haphazard development of the past, but that it is, directly and indirectly, a measure for true economy. Many local authorities have by now realised how much they will gain by preventing the erection of buildings or other works on routes which will be needed, sooner or later, for important thoroughfares or on sites which will be required for open spaces or other public purposes—industrial, residential or other—for which it is most suited, and, incidentally, securing transport facilities adapted to local requirements, particularly of industry, and they see the importance, generally, of making plans in good time so as to ensure that the operations of the private developer may harmonise with public needs, thereby often saving the necessity for public expenditure without any hardship to the owner, and also of taking precautions so that when public works have to be executed they may be carried out at a minimum cost.

The total number of local authorities which had proposed or were engaged in preparing town planning schemes on the 31st March, 1922, was 167, the whole area covered by these schemes amounting to 744,222 acres. Considerable progress has been made with the preparation of model clauses for town planning schemes, and it is hoped that it will be possible to issue them very shortly. During the year under report twenty Interim Development Orders were issued under Section 45 of the Act of 1919. Further Joint Town Planning Committees have been formed during the year and others are under consideration. These committees are advisory, their functions being to prepare an outline plan and statement of development for the entire region concerned and to advise on the co-ordination of the schemes of the various authorities as they progress.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE MECHANICAL DESIGN OF SCIENTIFIC INSTRUMENTS.

By PROFESSOR ALAN F. C. POLLARD, A.M.I.E.E., F.Inst.P.

LECTURE III. *Delivered March 6th, 1922.*

In the course of the lectures, reference has been made to the variance of measuring instruments, and we have examined various designs, one object of which is to reduce variance to a minimum. We will now examine in detail the different mechanical causes of instrumental variance. Before we do so, however, it will be as well to have a clear idea of the relation of variance to accuracy, and sensitivity, and we shall follow the extremely important notions of J. Schlink*.

It sometimes happens that the distinction between accuracy and sensitivity is not always maintained in the discussion of physical and engineering scientific instruments. The fundamental concepts are of course, quite clear.

An instrument is said to be :—

(i.) Accurate when its indications accord with the true value of the quantity being measured.

(ii.) Sensitive when a change in the quantity being measured is accompanied by a change in the indication of the instrument.

We know that we can never have perfect accord between the indications of an instrument and the values of the quantity being measured, so the definition is an ideal which is never attained. The various unavoidable mechanical limitations imposed by the coaction of the working parts, friction, alterations in the dimensions and properties of the instrument's elements with time, and the changes in the environment, of temperature, pressure, humidity, etc., and normally uncontrollable variations in the manner, frequency and rate of operation, all tend to make the accuracy of the instrument depart from the ideal. We require some quantity which will show us by how much the instrument departs from this ideal, and at a given reading the actual value of the discrepancy is termed a "correction."

In the common measurements of industry and commerce, sufficient accuracy is sought in the instrument so as to dispense with corrections, in order that the readings of the instrument can be used directly without a correction in a convenient manner.

But in laboratory instruments, or where greater accuracy is required, the instrument is calibrated against some standard and the corrections or errors are discovered at points closely set along the instrument's range.

Instrumental accuracy is usually expressed numerically, by defining the error or correction for various values of the quantity being measured. The error arising from whatever source, observed in an indication of the instrument, divided by the true value of the measured quantity may be termed the relative or *specific inaccuracy* at a given reading, the negative term being justifiable on the basis of custom and ease in application.

The reciprocal of specific *inaccuracy* may be termed *specific accuracy,* a ratio which is not of value in the ordinary use of instruments, but of service in rating the performance of an instrument.

By the commonly accepted definition already given, any instrument which shows a change of reading for any change, however great in the quantity being measured, is sensitive.

For particular instruments, especially those read by null methods, sensitivity has

*Bulletin *Bureau of Standards.* Vol. 14, p. 741.

often been expressed as the smallest change in value of the measured quantity which produces a perceptible response in the indicator of the instrument. Expressed in this way the term sensitivity is unscientific and loose, since differences in the observer's acuteness of perception or personal sensitivity would result in varying estimates of the sensitivity of the instrument.

Moreover, using the term in this way we should fail to distinguish between insensitiveness and sluggishness or want of response.

For example, the sensitivity of a balance was long defined as the smallest added load which effects a perceptible change in the position of the pointer.

Analytic balance makers even now express the sensitivity as "turning to so many milligrams." Obviously, the beam might be sluggish and it might turn to a smaller load than that stated if left to itself long enough. The definition has since been improved by measuring the distance the end of the pointer moves through for change of unit load on one of the scale pans. But this is not sufficient, for the sensitivity of any one balance could be increased by making the pointer longer.

A scientific way of measuring the sensitivity of a balance is to state the angular displacement of the rest position of the beam when unit load is added to or taken away from one of the pans.

In actual measurements of sensitivity of instruments the deflections of the indicator must be small, principally because the sensitivity may vary over the range of the scale. The deflection used in determining sensitivity must, therefore, be so small that variations over that range of deflection are quite negligible.

Sensitivity then is the rate of displacement of the indicating element with respect to change of the measured quantity, *i.e.*, $\delta\theta/\delta m$. But it may happen that on account of friction between the moving parts of an instrument some definite change δm in the measured quantity fails to produce any change $\delta\theta$ in the indication.

If, therefore, we plot as a Cartesian diagram, the indication of the instrument against the measured quantity, as shown in Fig. 33, we should have a zero sensitivity at some point in this "*measured quantity—indication curve*," which in reality has a definite slope or sensitivity at that point.

On this account it becomes necessary to draw a distinction between sensitivity and want of response.

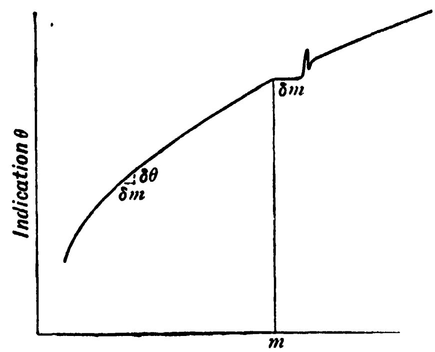


FIG. 33

In fact, it is often true that in less precise instruments a considerable change in the measured quantity can be effected without any motion in the indication of the instrument. This period of inaction of the indicator persists during the taking up of slack and the overcoming of the static friction of the operating parts.

We thus distinguish between instrumental "passiveness" or sluggishness and instrumental insensitiveness which was first pointed out by Schlink.

Passiveness may then be determined by noting the smallest alteration in the quantity to be measured which will produce any change whatever in the indication of the instrument.

The specific term :—

$$\text{Passivity} = \frac{\text{least change } \delta m \text{ in the measured quantity producing instrumental response.}}{\text{Initial value } m \text{ of the measured quantity.}}$$

In the diagram the curve at the initial value m becomes horizontal over a range δm and I have indicated the finish of this range by a small damped oscillation of the indicator in order to bring clearly before the mind the inactivity of the indicator, which being overcome by the growing forces acting upon it as the measured quantity increases oscillates about its position of equilibrium assumed to be on the curve.

We rejected the notion of a perceptible movement so far as it relates to sensitivity, but we may retain it for the definition of passiveness, since the passiveness evidenced by delayed response has been overcome so

soon as any motion whatever of the indicating element has taken place.

The notions with which we have just dealt are related to the measured quantity.

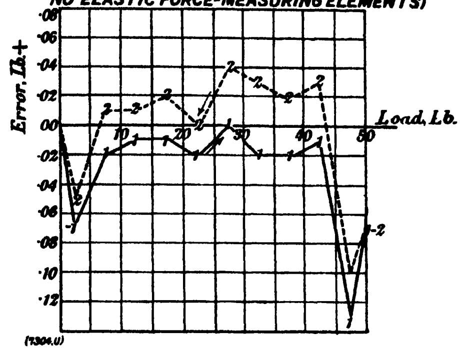
We now deal with a set of notions regarding the performance of the instrument which exclude the variation of the measured quantity and in which all changes of indication are intrinsic to the instrument itself and are not, *per se*, indicative of change in the measured quantity. The term, variance, conveniently covers these changes and it may be defined as the range, at any given value of the measured quantity, of variation in reading which may be exhibited by the instrument under repeated application of the same value of the quantity being measured, after a steady reading has been attained, the environment remaining unchanged. The specific variance or *variancy* is the ratio of this range divided by the value of the measured quantity itself.

Variance which overlaps passiveness is in reality the range of uncertainty of indication, when all the causes of variation save those inherent in the instrument are eliminated. This factor is rarely determined in tests on measuring instruments. Its neglect may cause appreciable error in conclusions inferred from the indications of the instrument, and its investigation will certainly expose instrumental imperfections of considerable and hitherto unsuspected importance.

In the case of the usual direct reading instrument, the variance is disclosed as the displacement observed between the upward and downward branches of a hysteresis loop when the instrument is subjected to a complete cycle of operation from a lower to a higher indication, returning again to the lower indication.

This curve, showing the errors in the readings of the instrument over its whole scale range, is a valuable, and, in fact, indispensable, index to the operating characteristics of an instrument, and affords information regarding defects of design and workmanship discoverable with certainty in no other way.

Fig. 34 shows the hysteresis loop of an automatic or self-indicating weighing scale of the cam-pendulum type, in which the load is balanced by the variable turning moment of a pair of oppositely rotating pendulums mounted on ball bearings, and which, therefore, comprises no elastic force elements. It will be seen how the aber-

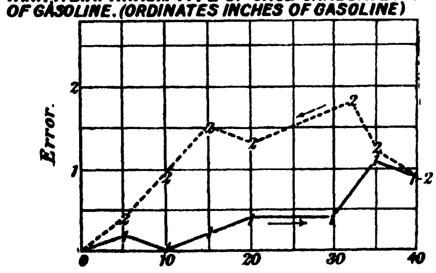


(*After Schlink*)

FIG. 34.

rations of the increasing readings are reflected in the curve of decreasing readings with a tendency to wider separation at the middle of the load range The hysteresis is certainly not due to elastic strain, though, no doubt, the elastic strain of the coacting elements contributes a small and negligible amount, as in all instruments.

The sources of this hysteresis loop are all expressible as back lash, or are closely analogous to it The next figure gives the



(*After Schlink.*)

FIG. 35.

hysteresis loop of a depth gauge for gasoline tanks, which is a diaphragm type of pressure gauge. The ordinates are in inches of gasoline and here, obviously, the variance is due to want of elasticity of the diaphragm. This type of variance is present in all instruments which use a spring element in equilibrating the changes in the measured quantity. The changes of shape of spring elements are always to some extent irreversible. The errors which the flexure of astronomical transit telescopes introduces into the readings of these instruments are

exceedingly troublesome and difficult to determine.

It would be interesting as well as extremely important to astronomical observation, if the hysteresis loop of transit instruments could be determined for the range of the instrument over the meridian. It might then be possible to analyse the loop into its types of variance and improve the design.

We cannot ever eliminate flexure from the parts of our instruments, but we can, by the choice of suitable material, and by design, reduce it to the necesary minimum. When a bar of material bends under load, the fibres of the material are stretched or squeezed, and we know that, if we do not exceed the elastic limit, the stretching or squeezing of the fibres is proportional to the load.

The intensity of the load is then, equal to the stretch or squeeze multiplied by a constant. This constant is the modulus of longitudinal elasticity or Young's modulus. Hence, if we choose a material with a large Young's modulus, the stretch or squeeze is less for a given intensity of load.

No one would dream of making the limb of a microscope of oak in preference to steel, and one of the reasons is that Young's modulus for steel may be 35 times as great as Young's modulus for oak. Generally speaking, instruments are mechanisms, but are not machines; that is to say, they are not mechanisms whose chief function is the transmission or commutation of energy. Their chief function is to maintain determinate geometrical relations between the links of the mechanism.

It is only necessary then to investigate the elastic aberrations of the geometrical relations, and to ensure that these elastic aberrations do not cause error at the indicator exceeding some determined fraction of a unit division of the scale.

Frequently the design of analytic balance beams shows great ignorance of the theory of framework. The correct shape of a balance beam is two equilateral triangles placed back to back, in order to secure maximum stiffness with minimum weight. The cross sectional dimension of the links of the framework should be settled by the permissible deviation of the knife edges from their original relative positions in the vertical plane when the pans carry the maximum load.

This permissible deviation is settled by the required sensitivity at the maximum load.

By using graphical methods (on the drawing board) of solving elastic problems, a straight prismatic piece of any cross sectional shape though defying pure analysis can easily be investigated and the correct form determined for a definite deflection under a given load. It is more troublesome to deal with a curved piece in which the radius of curvature is comparable to the dimensions of the cross section—it requires excessively accurate draughtsmanship.

The supporting parts of the framework, however, may be subjected to external forces during manipulation of the instrument which cannot be specified.

In these cases the model is the only source of information.

Another type of variance is due to friction, and we have already indicated this under the term passiveness.

The main type of variance is that due to back lash, and analogous mechanical imperfections.

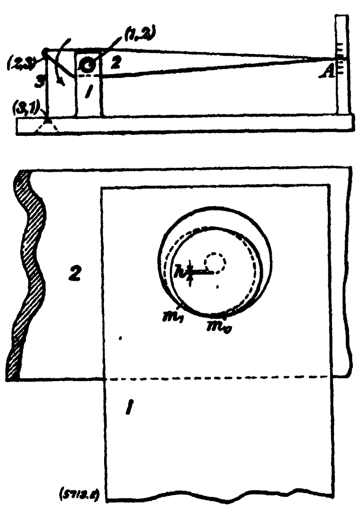
In instruments the chief function of turning pairs is to maintain constancy between the parts of the mechanism which transfer the forces or motions involved from the point of their reception to the point of registration or indication. This implies kinematically a constancy of virtual length in the linkwork if comprising only lower pairs or a constancy of determinate virtual length for any given configuration of the link work if comprising higher pairs. Let us examine the case of a single bearing having a loose journal thus representing the allowance for a running fit.

1 and 2 are two links of the mechanism of a measuring instrument. To fix the ideas the instrument may be a hair hygrometer shown in Fig. 36.

During operation the links 1 and 2 rotate about some more or less definite centre.

Assuming that force closure exists to keep the bearing and journal in contact at some point *m* and the hair 3 taut, the journal in part slides and in part rolls around the interior of the bearing, and its centre describes the arc of a small circle whose radius is equal to the difference of the radii of the journal and the bearing.

The point (1, 2) then for ordinary motions of the instrument will have motion in this arc, and it is at once evident that the movement of the pointer tip over the scale A does not bear a simple geometric relation to the change of length of the link 3.



(*After Schlink.*)

FIG 36.

In the case of a spindle rotating in ball bearings the exact performance may be different from the case I have just described, but the effect will be the same.

When the maximum sideways displacement of the instantaneous centre of rotation is reached, a more or less steady state of slipping takes place, so that as far as the hysteresis loop is concerned it is expected to be flat in this portion of the operating range.

The loop will then be made up of three phases—a lower lenticular portion, a middle oblong part and an upper lenticular portion This state of affairs can be demonstrated by experiment.

Clearance between teeth of engaging gears and racks introduces backlash effects of the same general nature as those outlined above.

In many cases the backlash of gear elements will be superposed upon that of turning pair elements.

In well made instruments the variance we have indicated will reproduce itself with considerable constancy, but in instruments which are badly made or in a state of ill repair, the hysteresis loops obtained in successive runs may be far from concordant in either shape or magnitude.

This irregular variance may be well expressed and defined by reference to a family of probability curves developed at various points along the instrumental scale.

Such readings in the calibration require, therefore, treatment similar to that required for "the errors of observation" by reference to the theory of probability.

Another type of variance is that due to drift and we have already referred to this in the case of aneroid altimeters. Drift is a time effect characterised by the gradual movement of the indicator asymptotically to a definite reading.

The cause of drift does not originate in the kinematic relations of the linkwork, but is due to an elastic after-effect present in almost all diaphragm instruments or a viscous resistance in the case of indicators, for example, moving in viscous liquids such as hydrometers, or the slow movement of heat through the protecting sheath of pyrometers, or temperature changes due to flow of current in certain electrical instruments.

The elastic after-effect is indicative of over-strain such as most certainly exists in the corrugated diaphragms of aneroids, for example.

From what has been said, it is evident that variance or the reproducibility of reading will limit the useful sensitivity, and the graduation of instruments is often found to be far closer than the large amount of variance justifies.

For testing or laboratory instruments, the mean interval of graduation should not be less than five times the mean variance, since observations may be noted accurately to 1/5th the smallest graduation.

For commercial instruments the unit of graduation may be to the variance in the ratio of 2 to 1.

It is obviously absurd to graduate a tachometer to one revolution per minute, when the variance may be as much as five revolutions per minute. Yet instruments are frequently graduated in this way. I have myself seen chemists laboriously reading burettes to 1/50th of a cubic cm., when the amount of liquid which clings to the walls of the tube will amount to several tenths of a cubic centimetre after the contained liquid has descended from a high to a low level.

Nearly all instrumental indications are references to a length which is proportional to the quantity being measured. Angular indications are referred to length of arc, areas by planimeter to length marked on the circumference of a drum, volumes by stereometer to length of liquid column, etc. Even in the analytic balance, weight is ultimately referred to the distance of the

rider along the beam, or the distance the pointer is displaced from zero position.

It sometimes happens that the length to be measured has directly applied to it a measuring rod in some form or other.

Such, for example, is the case when determining the height of the barometer. The level of the mercury in the tank is brought to some fixed level by observing the reflection of a fixed point in the surface, then the upper level of the column is determined by the coincidence of a fiducial edge with the meniscus, as seen through the irregularly refracting glass wall of the tube.

The late Lord Rayleigh* pointed out several years ago, that such a method of applying the two ends of the measuring rod in different ways is unsatisfactory, and in his accurate work upon gases he used measuring rods of iron for the manometers by means of which the differences of the mercury column heights were determined by the same physical procedure.

A vertical rod had its lower end pointed, and its upper end made into the form of an inverted stirrup from the centre of the horizontal limb of which a second point was directed downwards. The length between the two points could be accurately measured, and the coincidence of them with their reflected images in the two mercury surfaces of the manometer, insured a high degree of equality between the height of the mercury column and the known length.

We have now lightly touched upon a few aspects of the mechanical design of instruments in so far as their functional requirements are concerned, and in doing so, we have hinted at economy of production. Economical production is, of course, a gigantic field of activity, even when considered in relation to the manufacture of instruments, at which we can but peep.

But in doing so we shall learn that design having reached the last stage now divides itself into two main types—functional design and manufacturing design. In the early days the inventor brought to the mechanic his ideas and design was an outcrop of the mechanic's mind. He altered this or that part until the mechanism behaved in a way which pleased the inventor. The model was corrected and rebuilt before the design was completed. Duplicate mechanisms were copies of this model, possibly modified again by the mechanic's improvements or by the supply of material.

Interchangeability did not exist in these early days except in a prominent instance. The demand for wheels and pinions for clocks and watches became so great that the famous Dr. Hooke suggested a machine for dividing and cutting the teeth in wheels and pinions for clocks and watches in the latter part of the 17th century. The first machine, according to Hooke's notions, is said to have been made in France and to be similar to the machine figured and described in Bion's work on mathematical instruments, 1702.

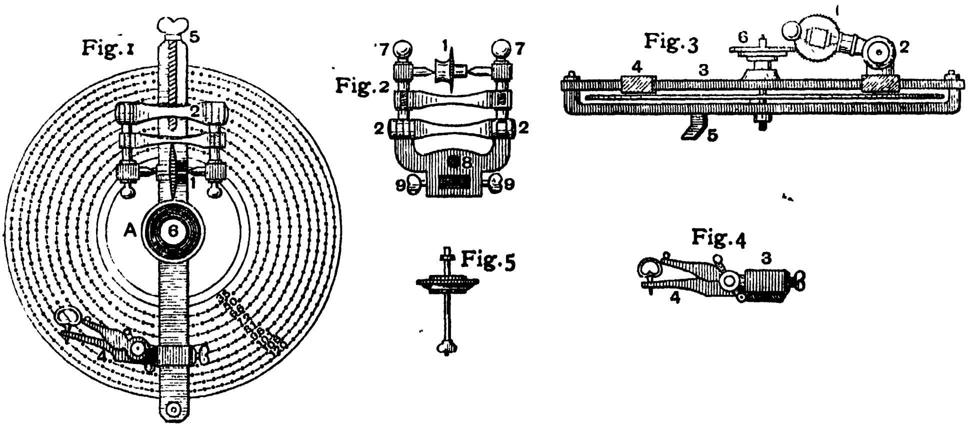


FIG. 37.

Fig. 37, taken from a later edition (1758 of Bion's work, shows this little machine in plan and side elevation, as well as some of its parts separately.

The plate A of brass, about 8" in diameter, has a series of equally spaced holes drilled in it on various concentric circles, similar

*Collected Papers. Vol. IV, p. 41.

to the dividing plate of some modern lathes.

The plate fixed to the arbor shown at Fig. 5 can rotate in the frame 3 and 5, Figs. 1 and 3. Along the bar 3 of the frame a carriage, Fig. 2, can slide and be clamped in any position. This carriage carries the milling cutter with its pulley 1 pivoted between two steel points secured by screws 7, 7 in the piece called the Porte-Touret, which in turn is pivoted at 2.

The thickness of the cutter is equal to a tooth space.

The disc to be cut is clamped to the arbor and the carriage is clamped to the bar in such a position that when the cutter is rotated by a bow, the string of which is looped round the pulley, and lowered upon the disc it cuts a tooth to the correct depth.

The spacing of teeth is done by rotating the plate and securing it in position by a fine steel point, Fig. 4, also clamped to the bar 3, engaging with an appropriate hole in the plate—in much the same way as division is done on some modern lathes.

This machine is probably the first which manufactured interchangeable parts.

The French were ahead of other nations in the invention of tools and apparatus for making clocks and watches.

In a work entitled Traité de l'Horlogerie Méchanique et Pratique par Thiout, Paris, 1741, there are detailed engravings of three gear cutting engines, two with perforated dial plates and one with a worm for spacing.

The manner in which the dial plates were divided is not clear, but about the same period Henry Hindley (a clock and watch maker of York) constructed a machine for cutting gears with a divided dial plate. In a letter to John Smeaton, of the 14th November, 1748, he describes how he divided the plate by a mechanical device, which we should call a "jig." So he may be regarded as the first inventor of the "jig."

Sketches and drawings next came into use to supplement the inventor's ideas, but all essential constructive detail was left to a competent mechanic and it was part of his training to supply the missing detail. More complete drawings which gave all the necessary dimensions and perhaps more closely specified some of the most important functional surfaces of component parts came later, and such drawings which specify the functional design, which aid the general construction of the mechanism and give general outlines of detail parts are largely used to-day.

But under the manufacturing conditions of to-day, with productive operations divided into elementary parts, with productive labour trained in specialised directions, with highly specialised productive equipment, with the economic necessity of interchangeability of parts, with the greatly increased rate of production and with large organisations, in which but a few individuals are conversant with all the detailed requirements of the mechanism and no one individual is capable of dealing with the mass of detail necessary for a complete and successful issue, the design must cover a wider field, it must be more comprehensive and accurate. Such design is manufacturing design, which cannot even be approached except by those who have had a comprehensive and intensive training as actual workmen in the shops.

Manufacturing design is a later and detailed development of functional design, and is in no way antagonistic to it, as some think. It, in reality, gives the information originally supplied by the mechanic in the early days.

It corrects and modifies the functional design to ensure economical and increased production.

It must ensure the ready assembly of the parts, so that the assembly costs are reduced to a minimum.

It must ensure that parts requiring attention in service are accessible, so that the service costs are reduced to a minimum. This latter requisite can only be completely determined after the instrument has been in service, for it is invariably subjected to abuses which the constructor never dreams of, but for which he is blamed.

Manufacturing design is never complete—improved methods of manufacture are constantly being developed.

It is true that manufacturing design will, in the course of time, work itself out in practice, but this is a slow and expensive experiment on a large and highly uneconomic basis. Continual alterations in equipment spell loss of interchangeability.

The experiment can be carried out on a smaller scale with better, speedier results, with more economy, and the use of models is from this point of view self evident.

These considerations do not interest the manufacturer of small quantities, but, nevertheless, to him as well as to the large producer, simplicity of design is the key to economy of production.

In addition to simplicity of design, there are a host of considerations the designer must keep constantly in view in order to fulfil all the demands of economic production. I refer now to that important, one might almost say branch, of design which requires a complete knowledge of not only how the various mechanical operations are carried out in shops and by machine tools in general, but more particularly in that individual factory which is constructing the instrument.

This essential knowledge can only be gained by an apprenticeship and close study during this important period of training, which is frequently regarded as a nuisance by manufacturers.

How a knowledge of manufacturing processes modify design has been set forth in a series of illustrated articles* which appeared in *Machinery* and which are worthy of careful perusal.

It is quite impossible for us to examine in detail examples of various defects in design from this point of view, but it will be advantageous to set out some of the practical points to be observed in the form of a list of precautions.

In the design of parts which will appear as castings, care should be taken to avoid :—

(*a*) Insufficient clearances between the surfaces of the casting, and other parts which may be assembled in proximity. It frequently happens that casting irregularities such as lumps due to the falling away of the sand in the mould, may foul another part during assembly, and interfere with continuous and rapid production.

(*b*) Coreing on small castings, which frequently necessitates unnecessary machining.

(*c*) Large cores with small outlets.

(*d*) Loose pieces on patterns which frequently get lost and sometimes displaced when ramming the sand in the mould, with the result of faulty castings.

(*e*) Insufficient metal on internal bosses which, being liable to displacement, may not stand up to machining.

(*f*) Complicated shapes. Design rather several pieces each of simple shape to be assembled subsequently.

In parts to be machined avoid :—

(*a*) Faces in enclosed positions. Neglect of this frequently requires the construction of special tools and nearly always embarrasses the machinist, resulting in bad finish.

(*b*) Blind holes, which frequently result in faulty work, due to the wandering of drills if special drilling jigs are not constructed and used.

(*c*) Internal slotting which is an expensive operation compared with shaping or planing.

(*d*) Insufficient landing space for planing tools in recesses or confined spaces. Room must be left for the tool to come to rest on reversal to the cutting stroke.

(*e*) Lugs, bosses or other extensions on faces to be machined.

(*f*) Several faces on different levels, necessitating a resetting of the tool for each face.

The stresses which are set up in castings by differential rates of cooling of the parts while the metal is in the mould or after the mould has been knocked away sometimes reach magnitudes that render the castings unsuitable for use, and in cases of some cast iron castings which have come under my observation have caused violent fracture to develop.

It is important that the cast parts of instruments should be free from these "initial stresses," which are subject to secular variation and to this end care must be taken that large masses of metal which have a low rate of cooling are not connected to small masses which have a high rate of cooling. The smaller mass having cooled acts as a rigid constraint to that portion of the casting connected to the larger mass which is still contracting.

Some interesting and very instructive experiments were carried out a number of years ago by Lieut.-Col. H. Clerk* on the curious behaviour of rings, hoops and other shapes of metal repeatedly heated and partially cooled in water, and the results were remarked upon by Stokes. These experiments seem to have been forgotten, but they should certainly be studied by the student of casting strains, and are of some importance in practical application, such as the tiring of wheels.

The instrument must be produced by established plant with the existing manufacturing equipment or new plant must be created. In both cases unless the volume of production is very large, all efforts must be made to reduce the machined surfaces of the components.

An excellent example of this has been kindly supplied to me by Mr. Stafford, of Messrs. Taylor, Taylor and Hobson, of

*Machinery. Vol. 14, p. 397; vol. 15, p. 705; vol. 16, pp. 527, 546.

*Roy. Soc. Proc. Vol. xii., 1863, p. 453.

Leicester, and is exhibited in the clinometer Mk. III., the War Office design of which is shown in Fig. 38 and the redesigned instrument for mass production is shown in Fig. 39.

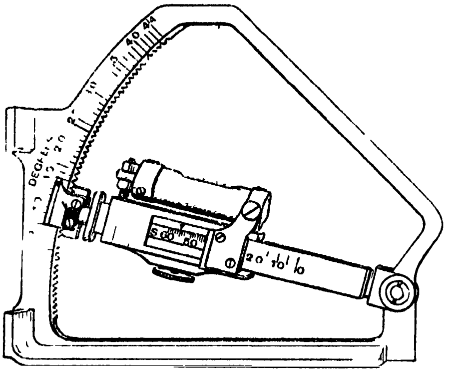


FIG. 38.

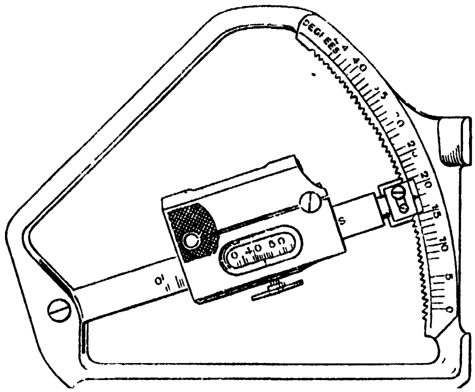


FIG. 39.

In the former the casting was machined all over, involving unnecessary work and expense and imposing an unnecessary limit to the output. The cost of this instrument was about £4 each and the maximum output about 40 per week.

In the redesigned instrument all parts were made interchangeable, the machined surfaces were reduced to a minimum and unnecessary operations were eliminated; thus reducing the cost to about half that of the War Office design. The maximum output was 250 per week, using approximately the same number of operatives, but employing accurately made tools and gauges to ensure rapid, interchangeable and accurate work. All unmachined parts of the casting are enamelled. Some of the details of the instruments are worthy of comparison.

The arm in the new design shows a much simpler form to manufacture than that in the War Office design. In the latter, the bar is machined with shoulders at either end, which serve the purpose of stops for the slider. This necessitates not only an exact length between the shoulders, but an exact length for the slider itself, an unnecessary complication avoided in the new design. The slider and bubble in the War Office pattern has a number of loose parts screwed together, requiring exact fitting, and the plunger side plates give little finger hold. In the re-designed instrument, the plunger side plates were made from drawn section pressed into shape, thus eliminating a good deal of the machining visible on the War Office model.

Another excellent example of a well designed mass production instrument is the refractometer, patented by Mr. William Taylor*, of Taylor, Taylor & Hobson, and manufactured by Bellingham & Stanley. The internal mechanism of this instrument has, in part, been described and shown in Fig. 20.

The manufacturing design must contain the specification of material.

As many parts as possible should be made of the same size and kind of material, which should be of standard sizes and forms purchasable in the open market at lowest prices. Frequently special and expensive material can be machined at a lower cost with resulting economy in product. For this reason special extruded bars are used in the manufacture of calculating, counting and type-writing machines, which, according to our definition, are instruments.

The source of supply of material must be considered—lack of material spells disaster to production.

Interchangeable manufacture itself involves the establishment of suitable limits on the functional surfaces, and means of enforcing those limits. By limits, I mean tolerances and allowances conjointly.

The limits are the laws of production, and the more liberal they are, the more economic is manufacture.

The importance of the correctly dimensioned drawing in this respect, apart from the specification, is emphasized by the frequent neglect of this important link in manufacturing design. There are two classes of drawings :—

*Patent Specification, No. 178, 290.

(*a*) Functional drawings ;

(*b*) Manufacturing or component drawings.

The functional drawings, like the functional design, specify the functional conditions to be maintained and the details which do not appear are supplied by the mechanic who uses them. They do not, for example, specify limits.

Manufacturing drawings, however, must supply all the information necessary for economic production.

One of the chief duties of the manufacturing drawing is to give the necessary tolerances and allowances of the components, so that they may be interchangeable, and in such a way that there is only one interpretation. It would be quite impossible, in the time at my disposal, fully to discuss the five rules of dimensioning which have been so ably laid down by Buckingham, engineer to the Pratt and Whitney Co.

We may, however, illustrate his first two rules by an exceedingly simple case, involving elementary and not composite surfaces.

Buckingham's first rule is :—

There is only one dimension (or group of dimensions) in the same straight line which can be controlled within fixed tolerances.

His second rule is:—

Dimensions must be given between those points which it is essential to hold in a specific relation to each other.

Fig. 40 (i) shows a stud dimensioned in the usual but incorrect way, for it violates the two rules given above.

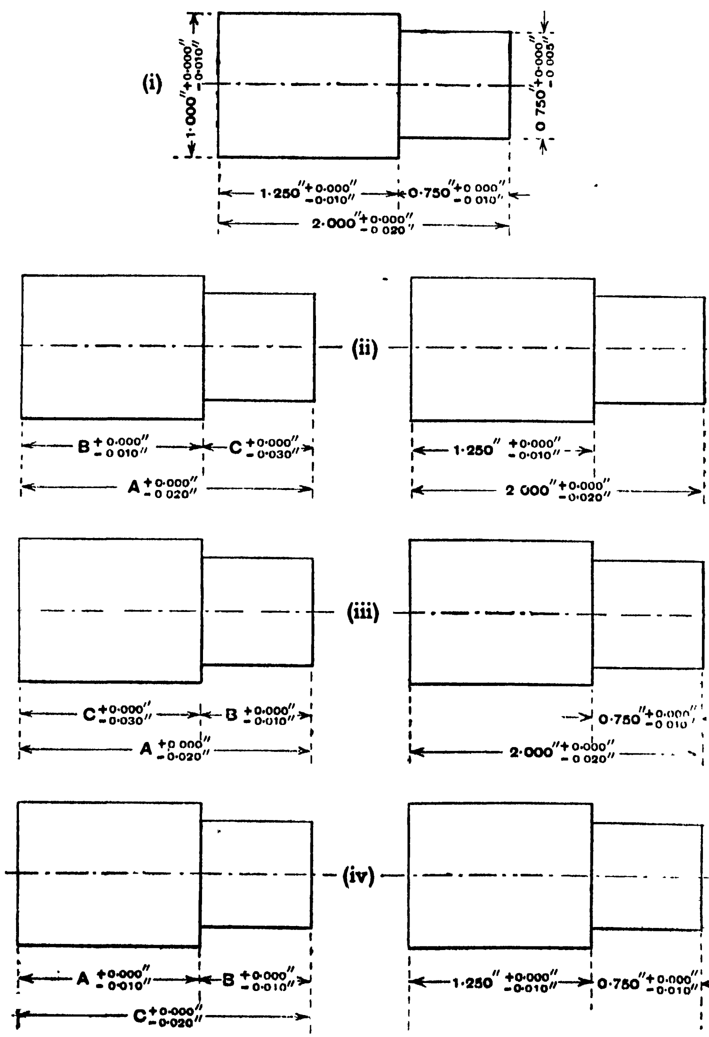


FIG. 40.

As the dimensions for the diameters are correctly given, we can eliminate those from the discussion and confine our attention to the wrongly given dimensions for the lengths.

Fig. 40 (ii) shows a possible sequence of operations indicated alphabetically. If we establish the overall length A and then the body length B, the stem length C may vary, ·030″ instead of ·010″ as specified.

Fig. 40 (iii) gives another sequence. If we first establish the overall length A and

liable to develop compound limits and the ambiguity must in all cases be avoided by suitable dimensioning.

The enforcement of limits is achieved chiefly by means of physical gauges.

These are well known to you, but I cannot refrain from describing the beautiful design of a limit gauge by Mr. William Taylor.

This gauge, originally intended for checking the diameter of the screws of photographic objectives and their flanges, is a geometrical design.

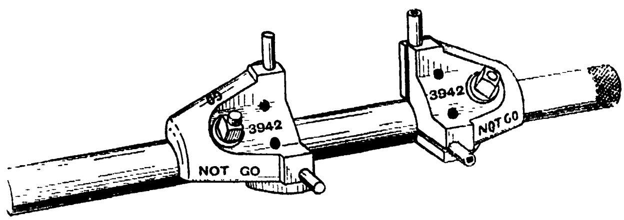


FIG. 41.

then finish the stem B the body length C may vary ·030″ instead of ·010″ as specified.

Fig. 40 (iv.) shows a third sequence, which is evidently the one intended, because the case happens to be the simplest possible. If we first finish the body length A and then the stem length B, the overall length C will be within the specified limits, and this last dimension is superfluous.

There are, therefore, three possible interpretations of the drawing, Fig. 40 (i), and these interpretations are correctly shown on the right hand side of the three lower figures.

If three different plants were manufacturing this part to drawing (i), it is evident that three different products might be received from them and interchangeability would be impossible.

The violation of these two rules alone could lead to utter confusion in components of complicated form.

I would like to have brought before you striking cases in which a violation of Buckingham's rules result in the imposition of closer manufacturing limits than are actually necessary for the functional requirements of a component and the importance of this cannot be overestimated for interchangeable economic production.

Confusion will also result from the introduction of compound limits. A compound limit exists when the application of a limit to one dimension develops a variation in another dimension, which also has a specified limit. Composite surfaces are

As seen in Fig. 41 the gauge consists of two steel sockets clamped on a truly cylindrical rod, each socket holding two hardened and accurately formed steel cylinders of specified diameter.

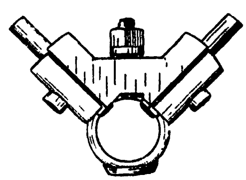


FIG. 42.

Each steel socket, Fig. 42, has one large and two small 45° V's cut in it, all three grooves being accurately at right angles to one another.

A ring with a threaded stem loosely fits the cylindrical rod and by a nut maintains moderate pressure between the rod and the two faces of the larger V groove in the socket. Thus the two sockets can be quickly and accurately clamped in any relative position on the rod.

By suitable clamps the small steel cylinders are held up against the small grooves, which are cut so that the axes of the two cylinders in each socket will lie accurately in planes perpendicular to the axis of the rod.

Three of these little cylinders have the same diameter. The fourth has a diameter exceeding the others by an amount which is equal to twice the required limit.

Suppose, now, the gauge is placed in its

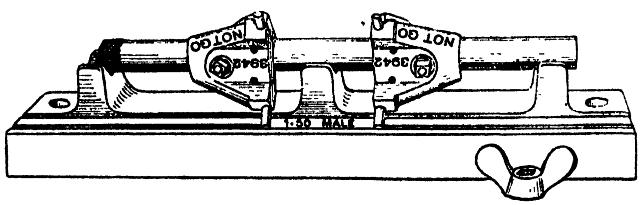


FIG. 43.

setting jig, as seen in Fig. 43, and the sockets clamped on the rod in such a position that a standard end gauge fits between the curved surfaces of two of the cylinders, with equal diameters. Then the inside distance between the other two cylinders will be less than the standard by the specified limit. In the same way, the measurement outside one pair of cylinders is greater than that outside the other pair, by the specified limit.

The gauge is a perfect adjustable working calliper gauge, which can be set to any reference end gauge, and the working surface of which can always be checked by micrometering the diameters of the gauge cylinders. These, if found to have developed flats, can be renewed by simply turning the little cylinders in their grooves.

Further, any limits for the gauge can be at once supplied from a set of fourth cylinders and the form of the whole device is peculiarly well adapted to delicate manipulation on a work.

The physical gauges of late years—especially during the Great War—have, in many applications, given place to optical gauges in which the principle of the interference of light is used, and others in which the shadow of the contour of the component is compared with that of a standard diagram, or that of a standard component.

An exceedingly beautiful optical gauge of the latter class is that of Wilson, for checking screw spindles in particular, or any spindle in general, which is constructed by Messrs. Adam Hilger, Ltd.

In conclusion, I desire to express my indebtedness to those who have made these lectures possible by generously lending valuable models and instruments.

I thank Mr. R. S. Whipple, of Messrs. The Cambridge and Paul Instrument Co., to whom time and trouble are of no account when helping others; Mr. Twyman, of Messrs. Adam Hilger, Ltd.; Mr. Ronald Taylor and Mr. Stafford, of Messrs. Taylor, Taylor and Hobson, Leicester; Mr. Swift, of Messrs. James Swift & Son; and Messrs. Bellingham & Stanley, for the loan of the beautiful instruments which have been shown.

My acknowledgments and thanks are also due to Mr. R. S. Whipple, and the Council of the Optical Society, for permission to use Figs. 13, 17, 18 and 19, and to the several sources from which many of the illustrations have been taken.

[At the conclusion of the lecture, the Wilson Projection Comparator was demonstrated by Messrs. Adam Hilger, and the lecturer showed the evolution of his totally submerged hydrometer, which is an instrument with five degrees of freedom, from the first conception and the first models.]

THE ESTHONIAN TIMBER TRADE.

The Russian Correspondent of the *Timber News* contributes some interesting particulars of the timber trade in Esthonia.

Ever since the end of the war the timber market of Esthonia has continued rather dull. The Esthonian Government had then just taken over the control of the State forests (managed before by the Russian Government) as also of the forests once belonging to private owners. The prices for hewn and sawn timber, which were fixed at that time by the Government Timber Department, were far too high to encourage the trade, and the export of Esthonian timber came, therefore, to almost a standstill.

When finally, in 1921, the prices were lowered by the Timber Department, the foreign markets experienced such a serious slump in business that the export trade was again unable to develop. This year, however, when the foreign markets seem to have reached a stable level, Esthonia is once more re-entering the British market with supplies of sawn soft-woods, sleepers and pitprops.

Esthonia's present production amounts to roughly 350,000 cubic fathoms per annum, of which nearly 300,000 cubic fathoms are absorbed by the home market, leaving about 50,000 cubic fathoms for export abroad. Most of the timber exported is consigned to the United Kingdom and consists of fir, those small quantities of birch which are cut being almost entirely consumed by Esthonia's own requirements.

The exports for the first three months of 1922 amounted to £40,000 against £20,000 in 1921. These figures will naturally experience a considerable augmentation during the summer months, when they may easily reach double their above-stated value.

Next in importance to the Esthonian softwood trade stand exports of plywood, articles manufactured therefrom, and furniture. The value of the export of all these goods in the course of the first three months of 1922 exceeded that of the softwood by £15,000, amounting to no less than £55,000. Considerable quantities of these goods were shipped to the United Kingdom, but Scandinavia, Germany and the surrounding countries also absorbed a fair proportion of them.

Esthonia's position would have become far more important than it is now had the stipulations of the Russo-Esthonian peace treaty matured, according to which Esthonia should have enjoyed the control over a considerable area of Russian forests. Like most of the Russian promises, this hopeful stipulation never became effective, and instead we notice the Russian Government dispatching their logs to the Esthonian mills (principally around Narva) to be sawn there for export. It should, therefore, be clearly understood that timber shipped from Esthonian ports need not always be of an Esthonian provenance.

There is no doubt that the Esthonian timber trade may look forward to great developments once the Russian concession becomes operative, but until then nothing exciting can be expected from these quarters, except that a limited supply of really good quality softwoods will be available this season and that considerable quantities of manufactured timber, as plywood, etc., will be produced in ever-improving quality.

VEGETABLE OIL AS MOTOR FUEL IN BELGIAN CONGO.

The extremely high cost of transportation of motor spirit into the interior of the Belgian Congo, largely due to tsetse flies, which make it impracticable to use animals for transporting goods and necessitate the use of native porters, led the Belgian Colonial Ministry to organize a trial of road tractors using palm oil as fuel The results of these trials, according to the official United States "Commerce Reports," have opened up vast prospects for the development of Central Africa, and may be summarized as follows:—

Palm oil, when used as sole fuel in semi-Diesel two or four cycle engines, gave full satisfaction. The engines ran normally, and the power developed is equal to, if not greater than, that obtained with kerosene. Nothing was noted that suggested possible difficulties in using palm oil in these engines. Starting up, without motor spirit injection, is good, and there is no carbonization. One large firm, which holds diamond and rubber concessions, possesses three tractors that run on palm oil and have ordered two more, very satisfactory service being rendered by those which have been in operation. These tests would indicate, then, that vegetable oils, which are so abundant and cheap in the tropics, can replace other fuels for semi-Diesel engines which are suitable for tractors, as well as other vehicles and machinery.

PERSIAN RUG EXPORTS.

In the 12 months ended March 20th, 1921, Persia exported rugs weighing in the aggregate 698,150 batmans and valued at 50,035,660 krans (1 batman equals 6.5 pounds approximately; the average exchange rate of the kran during the period in question was 50 05 to the £1).

The following table gives details of this trade:—

Kinds.	Quantity.	Value.
	Batmans.	Krans.
Wool carpets, without aniline	437,891	33,544,182
Wool carpets, aniline dyed	251,107	16,421,601
Silk carpets, without aniline	16	6,400
Silk carpets, aniline dyed	136	63,477

From a report by the United States Consul at Teheran it appears that the principal regions of manufacture of wool carpets without aniline were Arak, Tabriz, Kerman, and Hamadan, these four places accounting for over half of this kind of carpets exported. Aniline-dyed wool carpets were produced, principally at Arak, Hamadan, Tabriz, Shiraz, and Kerman, these five regions producing three-quarters of this class of carpets exported. Silk carpets without aniline are manufactured entirely at Kashan, while aniline-dyed silk carpets are made in Kashan, Tabriz, and Shiraz. "Arak" or Sultanabad rugs include those varieties which are known as Mohal, Sarouk, and Kenere (each of these in turn being sub-divided into fine, good, ordinary, and inferior qualities), while "Hamadan" rugs comprise those of the Mossoul variety and are generally known by the latter name.

The year's exports of wool carpets went chiefly to the United States, 281,000 batmans; Turkey, 136,000; British Empire, 96,000; Mesopotamia, 80,000; and British India, 64,000 batmans. Silk carpets were shipped for the most part to Turkey, 53 batmans; United States, 43; British India, 26; and France 19 batmans.

BLANKET TRADE OF THE ORINOCO VALLEY.

No single dry-goods article enjoys a larger sale in the Orinoco Valley of Venezuela than blankets, reports the United States Consul in Trinidad. They are used by the llaneros when driving cattle long distances, by those who gather forest products such as balata, tonka beans, and chicle, and by persons engaged in alluvial gold mining, all of whom customarily sleep in hammocks at night with blankets thrown over them for warmth and for protection against the elements Furthermore, although the climate of the Orinoco Valley is tropical, the nights are cool and windy, and as the ordinary Venezuelan bed has only a mattress, a pillow, and an under-sheet, those who travel about usually carry blankets with them. The kind most preferred is a cheap-quality cotton blanket, with a design of coloured stripes and flowers.

The "cobija forrada," or lined blanket, obtained exclusively from England, is in general use among cattlemen and those who go about the country on horse back. It is made of old wool, or bayeta, in two layers, one red and one blue, fastened together with threads and with an opening in the centre for the head. These blankets cover the rider very loosely like a poncho and thus permit free use of his hands, but they afford adequate protection against both cold and rain, and the Venezuelan rider looks upon them as indispensable The lined blanket is supplied in large quantities in the Orinoco River Valley, the retail price being from 50*s*. to 84*s* each.

GENERAL NOTES

New Zealand Butter and Cheese.—That the New Zealand dairy industry is big enough in its aggregate export output to make itself felt on the British market is increasingly demonstrated as the present great producing season draws in. Up to April 30th, according to *Ice and Cold Storage*, the gradings amounted to nearly 46,000 tons of butter and 60,000 tons of cheese. The Auckland district alone has contributed over 25,000 tons of this butter, notwithstanding a substantial share in cheese production, and the big quantity of dried whole milk manufactured there. The three-skim-milk powder factories of the New Zealand Co-operative Dairy Co. closed down in April for six months owing to the fact that sufficient powder had been made this season to meet the trade requirements for some time ahead. Butter manufacture is proceeding, however, in connection with these establishments. A number of dual-plant factories in various districts reconverted to butter-making in April. It has been estimated that the dual plants influence the country's cheese output to the extent of 25 per cent. when they switch on to butter, or *vice versa*. As to the London market, it has been extremely gratifying to note the recent approximation of New Zealand butter prices to those of Danish, and to note, in fact, that on at least one occasion the quotation for New Zealand butter topped the Danish price. It is considered that the extra uniformity of the New Zealand article, derived chiefly from our larger factory units, has had an important influence in the price movement referred to.

Industrial Development in India.—The *International Sugar Journal* records substantial progress with the Nira Valley Sugar Co., floated by Lalubhai Samuldas, of Bombay. Located at Baramati, about 100 miles south east of Poona, the factory is in the centre of a district where 30,000 acres of irrigated Pundhia cane are grown annually. As only 400 tons of cane per day can be dealt with, there should be no difficulty in obtaining an ample supply of raw material. The factory, which will be ready to operate in December next, is thoroughly up-to-date in its design. It will have a 14-roller mill and quadruple effect evaporator laid out for separation of steam to both heaters and pans. Sulphitation of juice and syrup will be employed, and the latter will be filtered before being sent to the pans Plant for double curing of the massecuites has been installed, and one grade of white sugar, or first and second and third grade may be turned out at will. A note issued by the Secretary of the Sugar Bureau at Pusa shows that in India there are at present 18 factories refining raw sugar, gur or rab

Cotton in the Belgian Congo.—According to a report by the United States Commercial Attaché at Brussels, there are at present in the Belgian Congo between 50,000 and 60,000 small native farms raising cotton and producing on the average 600 to 800 kilos of unginned cotton per hectare (kilo = 2.2046 pounds; hectare = 2.471 acres). The plots sown to cotton are extremely small and run as high as 10 to 20 to the hectare. Reckoning 476 pounds to the bale, the yield of commercial ginned cotton would amount to approximately one bale per hectare. The present production is estimated at 3,700 bales of 476 pounds each.

New Kauri Gum Process in New Zealand.—According to a report by the United States Consul at Auckland, a new process for cleaning kauri gum, used largely in varnishes, has been devised in New Zealand, and the delivered product from this operation is 98 per cent. pure as against 80 to 85 per cent. in other processes. It is claimed that this new method of treatment, which has been in operation for a few months, will reduce the time of treatment of the gum from the swamp face to shipping package to two hours, and will reduce the cost by about £3 per ton.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

COUNCIL.

On Monday, the 9th inst., the Council elected Sir Aston Webb, K.C.V.O., C.B., P.R.A., a member of the Council and Vice-President of the Society, in place of Viscount Northcliffe, deceased.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE CONSTITUENTS OF ESSENTIAL OILS.

By Lionel Guy Radcliffe, M.Sc.Tech., F.I.C.

Lecture I.—*Delivered March 20th*, 1922.

Historical Introduction.

Essential oils may be defined as volatile, more or less oily aromatic substances occurring in various parts of many different plants. Generally these oils are highly complex mixtures of definite chemical compounds and these individual constituents are to form the subject matter of the lectures.

Chemical research, aided by purely physical methods, has isolated and identified the principal odorous constituents of many essential oils, though much remains to be done, especially in regard to the identification of those constituents which only exist in the oils in exceedingly small amounts and yet exert a very pronounced effect on the odours of such oils. It is, therefore, very clear that the essential oil industry or in a more extended sense, the perfume industry, has received the very considerable attention of chemists in the past, but never more so than at the present day; still, until recently this country had seriously neglected the distillation of essential oil yielding plants and the manufacture of odorous substances and, indeed, the whole industry was on a very limited scale compared with Continental nations. To this aspect a return will be made later.

It may be truthfully said that in considering the history of the development of the perfume industry, it is in a large measure a recognition of the advances which have taken place in the apparatus used through the ages for the process of distillation. It is an accepted fact that knowledge of the art of distillation dates from the remotest antiquity, but it can only be conjectured as to the precise period at which the practice was discovered. There is but little doubt that in the first instance the delight of man in the fragrance of flowers and fruits led to the desire to possess the odours themselves in a tangible form and available at times when it was no longer possible to obtain the flowers themselves; further, there is much reason to believe that the rose was the first perfume flower to be treated by distillation, whereby what Maeterlinck has called "the imprisoned soul of the flower" was obtained as a beautiful smelling oil known to us now as "otto of rose."

The modern conceptions of essential oils and their chemical constituents began about 1882, and it became clear that most essential oils were composed of two main ingredients, viz., a terpene, which was a compound of the elements carbon and hydrogen only, and that this was mixed with the second ingredient made up of other substances, which we now know to include nearly every class of organic compound.

At this stage brief reference must be made to the importance of the geographical distribution of essential oils. The British Empire can, and does, produce the raw materials which yield a great majority of the essential oils, but until quite recently full advantage has not been taken in this country of our resources and opportunities. Few will dispute that the ideal condition of a given industry is that the raw materials found in a country should be converted into

the finished article in that country, but this principle, though, of course, recognised, has not been fully appreciated so far as the essential oil industry is concerned, and this mighty empire has allowed the foreigner to buy the raw materials in various parts of our Empire and carry them to his own country to work up into intrinsically valuable oils and the like, and then merchant them to us at prices fixed by himself. Still, it must not be forgotten that this country does labour under some insurmountable disadvantages, inasmuch as certain plants will flourish and certain will not flourish in our climate, and this limits our perfume manufacture to some extent; but we must look over our household, as the Empire includes every kind of climate, and it behoves us to see what can be done within the confines of that vast area upon which the sun never sets. It should be better known that our Colonial Governments have been for some years making efforts to cultivate profitable essential oil-bearing plants, and in conjunction with the Imperial Institute valuable results have been obtained and the prospect should be alluringly bright.

Although it is not the object of this course to deal with the manufacture of odorous substances, but rather with the constituents of such substances, it is necessary briefly to outline the methods of extracting the odours of flowers and the oils from plants, and in this connection our neighbour France holds the pride of place so far as floral perfumes are concerned, and this, both on account of the wonderful climate of the South of France, and the skill and devotion of those men who have given their lives to the study of the facilities and opportunities offered to them by their own country.

Just at the moment the perfume industry is having an anxious and vexatious time, the law for the safeguarding of industries, the question of duty-free alcohol and trade depression are each adding their quota of troubles, but there is no doubt that these difficulties will be overcome, and with a proper understanding of the raw materials available within the Empire, British tenacity and the skill of our chemists, will raise up an industry second to that of no other country in the world, but it means research and costly research at that, and there is yet to be established a central research association for the perfume industry, and this should come into being at once and be liberally supported by everyone connected with the industry and directed in a truly liberal spirit.

In very briefly reviewing the methods used for the extraction of odorous substances from plants, mention may be made of the knowledge, etc., which must be available before the extraction proper can be undertaken. A serious scientific study must be made of the conditions of cultivation required for each odorous plant, this including scientific manuring, etc.; the exact age of a plant at which the maximum yield of the desired essential oil can be obtained, must be chosen as the time for harvesting and the best process, distillation or otherwise, must be used for the extraction of the material, and in addition to this knowledge the raw plant materials frequently require a preliminary treatment, such as rasping, in the case of oil bearing woods, or crushing and grinding for odorous seeds.

The extraction of the odours from delicate flowers is at once a science and an art, and may be illustrated by reference to the floral perfume industry as carried out in the South of France. Probably the most important district in this connection is the Department of Grasse, situated on the Mediterranean sea, and behind it the Alpes Maritimes and the principal town of Grasse itself, situated on the hillside about 1,000 feet above sea level, has an almost perfect climate, so much so that flora of this portion of the Riviera may be said almost to reproduce the botany of Europe. In the Alpes Maritimes, lavender plants (*lavandula vera*) are distilled in quite small, simple and portable stills, arranged in the open air. The plant material is placed in the still with water, and the whole heated over a naked fire so that the steam carries over with it the essential oil, and the mixed vapours are condensed in primitive coolers, which consist of a coiled pipe, immersed in cold water, contained in a kind of barrel.

On a large scale, there are several methods of distillation such as dry steam distillation, with saturated steam under pressure, or with superheated steam, or a simple distillation with water, whilst methods of continuous distillation, and distillation in partial vacuum, are all practised. The stills are exceedingly varied in design, and are often quite elaborate, but time does not permit of a description of these. In connection with distillation methods, it must be kept in mind that in nearly every odorous

material, the exquisite freshness of the original perfume suffers by the process of steam distillation, and the longer the material is in contact wth the steam, the greater is the general deterioration of the perfume. At this stage, and in connection with lavender, it must be pointed out that the English grown lavender is quite different from that grown in the South of France, and is accounted a much more beautiful perfume, and in the chemical examination of lavender oils, this difference in the two lavenders must always be kept in mind, and the judgment of the nose added to that of the chemical test.

Returning to the perfume industry, in the South of France the extraction of delicate flowers is carried on by a very different process from that described above. Such flowers as the violet, jasmin, cassie, orange, rose, mignonette, tuberose, etc., are treated by methods which do not alter the most subtle and delicate characters of the perfumes. It will be understood that the cell membranes of flowers are very fragile and easily broken, and that once this happens, the various substances contained in the cells come in contact with one another, and frequently cause changes so that the delicate perfume becomes changed in the flower when once the petals have been bruised. To avoid such damage, the following processes have been devised, and many of them are historically very old. In the first place, there is the method of extraction by fixed, *i.e.*, non-volatile solvents, which, practised with the cold material, is called "enfleurage," and with the hot fixed solvent is designated "maceration." Such delicate flowers as jasmin and tuberose, contain only a portion of the perfume material, which they are capable of yielding, in the free state, so that a method is used which does not kill the flowers, and which permits of the further development of their odorous constituents and the absorption of these, as they are set free by the plant, *i.e.*, the cold or "enfleurage," process. The flowers, after being weighed, are transferred to a table and undergo a process of picking, having for its object the removal of unwanted material, such as leaves and twigs; then the flowers are ready for the treatment proper. The apparatus used is a large wooden frame furnished with a glass bottom so as to produce a tray, which is called a "chassis." The upper surface of the glass is spread with a layer of fat, and on this the fresh flowers are scattered. At the same time, the bottom of the tray is also coated with the fat, and the trays are made so as to fit one within the other; these are piled in tiers so that each batch of flowers is standing on fat, and has a layer of fat above it to absorb any volatile oil which the flowers may give off, and so the perfume of the flower, gradually disengaged, is absorbed by the fixed fat. Actually, the time required for the flowers to be exhausted of their perfume varies with different flowers; for example, the jasmin flower takes about 24 hours, after which the exhausted blooms are removed and replaced by fresh ones, and the treatment is repeated until the fat has acquired a sufficient strength of perfume. The resulting perfumed fat, known as the "pomade," is the raw material from which the perfumer manufactures his artistic confections. This process is a very lengthy one, and includes the whole period in which the flowers bloom, enormous bulks of flowers are required, and many thousands of trays are in use at a time, in such factories. A "chassis" is about three inches in depth, 24 inches in width, and 38 inches in length, and has placed on it about 1lb. of fat in all. One of the oldest forms of perfumed fat is perfumed oil. To make this, the glass bottom of the chassis is replaced by wire-netting, on which is placed a piece of wool or coarse cloth saturated with olive oil, and again the flowers are placed on the oiled material and the perfume is absorbed.

The warm process of enfleurage or maceration is applied to such comparatively stable flowers as the violet, rose, orange flowers and cassie flowers. In the process of maceration, large tinned basins, called "bugadières," standing on water baths, contain the melted fat, and in this are placed the flowers, which are kept submerged at a temperature of about 65°C. for about half an hour, when the flowers are removed, drained and taken to a press to remove adherent fatty matter, which is returned to the main bulk. Many treatments with flowers are required, and, roughly, anything from 5 to 25 lbs. of flowers, according to their nature, are required to perfume adequately a pound of fat. In some factories, pure olive oil is used instead of the fat, and is kept heated by a water-bath, and the flowers immersed in it as before, and, in general, the shorter

the time of contact between flowers and warm oil, the more delicate is the resulting perfume. Various devices are in use to reduce the time of maceration; for example, one consists of a reservoir containing the fat heated to about 65°C., from which it flows in a slow stream through the macerating chamber, consisting of a long tank in which wire cages containing the flowers are suspended in open compartments. From time to time, the basket nearest the oil reservoir is emptied and all the other baskets are moved on one compartment, whilst a fresh basket of flowers is added at the other end, this resulting in a constant movement of the oil and the flowers, in opposite directions, whereby the time of maceration is materially reduced.

The extraction of the odorous substance from these fatty materials is a simple, but rather lengthy, operation, and to achieve this object, use is made of the fact that the odorous material is soluble in alcohol, whilst the fat or oil is very sparingly dissolved by the spirit, and thus an alcoholic extract of the floral pomade can be obtained. For the manufacture of such alcoholic extracts called "triple extracts or quadruple extracts," according to their degree of concentration, the pomade or perfumed oil is well beaten up in machines called "batteuses," with cold alcohol. Actually, these machines are closed vessels fitted with mixing gear, so that the fatty material is brought into thoroughly intimate contact with the alcohol. After the extraction is complete, the alcoholic mixture is chilled to about 15°C, this having the effect of throwing out of solution any small quantities of fat or oil which may have become dissolved during the churning process; the alcoholic solution is then filtered through a small closed press, and the resulting extract is the material used by the perfumer, or, from it, can be extracted the individual constituents contained in the odour of the plant. The residual fat which has been thus exhausted with alcohol, still retains a considerable amount of odour, and is a useful material for soap makers, being sold to them under the name of "corps épuisé."

A totally different process for the winning of the perfume of flowers first came into use about 90 years ago, and was developed into an industrial process about 1897. In this process the odorous plant material is treated with a volatile solvent which dissolves the perfume and certain other substances, and from the resulting solution a concentrated odorous substance is obtained by evaporating off the solvent. Much knowledge is necessary in the choice of a suitable solvent, and the proper method of applying it so that the delicate aroma of a particular flower is not injured during the evaporation of the solvent. Such a solvent must dissolve the whole of the odorous constituents contained in the flowers, and it must not have any chemical action on the individual constituents; further, it is obvious that it must not leave any odorous residue, inherent to itself, on evaporation, and it must evaporate in a vacuum at temperatures so low that the most volatile odorous constituents do not distil off at the same time, and are not affected by the highest temperature required to remove the last trace of the solvent, and, of course, such a solvent must be obtainable at a price which does not prohibit its use on a large scale. It is not possible to go into any considerable details, and it may serve to mention that petroleum ether is frequently used on account of its solvent properties. and the ease with which it can be distilled and recovered. In outline, the plant material is treated in closed vessels with the petroleum ether which from time to time is drawn off and brought in contact with more of the fresh odorous plants, the process is continuous, each time the material being treated with the petroleum ether distilled off from previous extractions. Beautifully designed plants are used, having for their object the convenient handling of large bulks of raw material, the recovery of the solvent and the isolation of the odorous principles, every regard being paid to the conservation of labour, materials and heat.

The highly complex mixtures which are left after the vacuum distillation of the solvent contain a considerable quantity of extraneous matter, i.e., matter which is not odorous and which is coloured according to the nature of the flowers. Much of this extraneous matter is of a wax-like character, and some years ago the writer and J. Allan investigated the wax from the jasmin flower. The material had been treated for the removal of nearly all the odorous constituents and was in the form of a hard yellowish brown substance, having but a slight odour of jasmine. As the wax was found to contain a little alcohol, this

was removed by keeping the wax molten until no frothing was visible, after which is was used for the following examination:—

The solidifying point, as in the titer test, was between 56°C and 57°C. The examination with the Zeiss butyro-refractometer was a little difficult on account of the high melting point of the wax, but the following figures were obtained:—The scale reading at 84°C was 30; 74°, 33; 70°, 36; 65°, 38; 62°, 40; 60°, 42; 56°, 44.

It is interesting to know that Lewkowitsch gave for beeswax at 62° the reading 29·5 to 30. The acid value was determined on 5 grams of wax dissolved in a mixture of neutral alcohol and ether; it corresponded to 2·8 grams of potassium hydroxide form 1 gram of wax.

The wax was difficult to saponify, and the saponification value was determined by dissolving the substance in neutral amyl alcohol, adding alcoholic potash as usual, and boiling for five hours on a sand-bath. The final result was that 65·8 mgms. of potassium hydroxide were required per gram of wax, whilst, when using sodium ethylate for the saponification, 63 mgms. were required. The iodine value of the wax by Wijs' method was from 52 to 53 per cent.

The fatty acids were isolated from the saponified residues in the following manner: The residues were boiled with a large volume of water until all the alcohol was expelled when the unsaponifiable matter separated out as a white scum; this was skimmed off as completely as possible and was proved not to be an insoluble soap by its solubility in ether, its low melting point and the fact that it left no residue on ignition. Subsequent experiments showed that it was very difficult to remove the whole of this unsaponifiable matter from the fatty acids which were precipitated on acidifying the soapy liquor; however, by repeatedly dissolving the fatty acids in alkali, extracting with petroleum ether, and reprecipitating with acid, a hard white mass was obtained having a mean molecular weight of 398 and an iodine absorption of 39 per cent. It was not found practicable to obtain sufficient of these fatty acids to enable the titer test to be done, but when recrystallised from boiling alcohol the mixed acids melted slowly between 57° and 65° C. The unsaponifiable matter from ether yielded a mass of well-crystallised white needles, having a sharp melting point of 64° C. On heating this unsaponifiable matter with soda-lime, hydrogen was evolved indicating the presence of alcohol, and eventually an acetyl derivative was obtained melting at 45°, but the amount was too small for analysis to be made.

The presence of such waxlike matter renders the residues from the petroleum ether extract of flowers, semi-solid or even solid and at this stage this highly odorous mixture is called "a concrete." Needless to say, they closely resemble the original delicate perfume of the flower and for this reason they are sometimes called "absolutes." There must be no misunderstanding that the preparation of such concretes is easy: in reality, it is a highly skilled operation for which the most intimate knowledge of the raw material is absolutely necessary, and the mechanical devices are also quite intricate. Once more attention must be directed to the fact that such concretes are mixed with much inodorous material, and it is very difficult to separate the odorous principles from the wax as this latter retains odour in a most tenacious manner, so that a still further process is used whereby the wax is separate and the odorous portion obtained. The exact processes used are rather largely trade secrets, but in outline the concrete is dissolved in a solvent which gives a perfect solution of both the wax and perfume substances, and to this solution is added a second liquid which throws the wax out of solution and leaves the odorous oil in solution, the mixture is then filtered and the solution distilled at as low a temperature as possible when there remains behind an oil representing the mixed perfume substances which constituted the odour of the flower, in the highest possible degree of concentration. Such flowers as the broom, carnation, cassie, jasmine, jonquil, mignonette, mimosa, narcissus, orange, rose, tuberose and violet, are treated by these processes. In this connection mention must be made of the extremely small quantities of odorous material which are actually obtainable from the flowers—in the case of the jasmin over 1,000 kilos of blossoms yield about 4 kilos of ordinary concrete or slightly less than 2 kilos of the absolute flower oil, whilst the neroli bigarade, the blossom of the bitter orange, only contains from 0·05 to 0·1 per cent. of the odorous oil and the other flowers about the

same or in some cases even less. It will be easily appreciated that floral oils prepared in this way are most costly substances and they are frequently so expensive that few perfumers can afford to use them, and this is especially true at the present time when the cost of production has so increased. It is therefore necessary for the manufacturer to offer these floral oils diluted with some inodorous material such as ethyl phthalate and the like; this is a regrettable innovation but business conditions have apparently rendered it necessary.

To return for a moment to some of the oils obtained by the steam distillation processes, neroli oil, from the flowering orange tree, requires one ton of blossom to give about 35 to 40 ozs. of the odorous oil, the red rose cultivated in the South of France needs eight to ten thousand lbs. of roses to yield about a lb. of the otto of rose, whilst the French lavender flowers give about 1 lb. of oil from every 70-80 lbs. of flowers, and 112 lbs. of the fresh English rosemary herb yields about 24 ozs. of the oil, and in the case of the red rose grown in Bulgaria, it has been estimated that 100,000 roses only give about 1 oz. of otto of rose. These figures have been quoted to illustrate the small amount of actual perfume contained in many of the odorous plants, though, of course, there are plants from which greater yields are obtainable, and this is more especially true of the plants grown in the tropics. With such costly products as the raw materials it will be appreciated that it is not every chemist who can carry out researches on the isolation of the individual constituents contained in these oils as such investigations necessitate the use and destruction of large bulks of exceedingly costly material, which must be prepared from vast quantities of raw material, and therefore research on this subject must have adequate financial assistance such as is available when large firms undertake research or by the help of the Government; and in this connection mention must be made of the work carried out by J. L. Simonsen and his staff, at the Forest Research Institute, Dehra Dun, India, and also the splendid work done at the Imperial Institute. While such work is very costly there is no doubt as to the valuable results which must result therefrom, and several firms, especially in Germany and France, have contributed largely to the knowledge of the constituents of essential oils, and have reaped no little commercial success from the labours of their highly skilled and specialised staffs, and it is for this country to find means whereby we also shall progress in this direction.

The study of the odorous constituents of plants has occupied the attention of chemists for approximately the last 40 years, and now a great industry has arisen from their labours, viz., the artificial preparation and isolation of individual odorous organic substances which have been proved to be constituents of floral perfumes, and the quantitative determination of the individual compounds which are contained in a natural perfume, this leading to the blending of the various synthetic compounds in proportions which yield a mixture, having a more or less close resemblance to the inimitable products of nature. It is regrettable that one of the applications of the knowledge of the constituents of essential oils has been the elaboration of scientific adulteration, and this has reached such a state of perfection that the examination of essential oils for purity necessitates a very complete chemical and physical testing, not forgetting the use of a thoroughly trained nose. Still, as E. Charabot said: "the natural perfume industry and the more chemical industry of the production of synthetic odorous substances though rivals in appearance, lend each other mutual support in the path of progress on which they are both travelling, and thus there is one more instance of the truth with the fruitful instruction which it bears with it, that real continual progress, universally beneficial, is invariably shown when science and industry are bound together in close union."

THE WORSHIPFUL COMPANY OF THE WOODMONGERS AND THE COAL TRADE OF LONDON.

By Hylton B. Dale.

The Mysterie of the Woodmongers and Coal Sellers, sometimes called the Fuellers, was of very old standing. It enjoyed its greatest prosperity in the 17th century, when it had the carmen added to it and received a Royal Charter, but fell from grace and had to surrender it 65 years later.

As early as 47, Henry III. (1263 A.D.), we hear of Alice, daughter of Peter le Wodemongere, and it is probable the

company was going in 1330, as the Coal Meters were formed in that year and the first Government tax on coal was raised in 1368 to pay for the last campaign of the Black Prince.

The "Mysterie of the Woodmongers" made its first known public appearance in 1376, when the Livery Companies were summoned to send representatives to form a Common Council to assist the Court of Aldermen in the governance of the city. The Woodmongers sent two representatives, viz.:—John Asshurst and William Schrympelmershe.

In 1306, and again in 1400, the nobility and citizens of London petitioned the King to prohibit the use of pit coal, but their petition was ineffective on both occasions in spite of a commission of Oyer and Terminer.

Coal was then chiefly used for brewing and soap making, which trades were carried on in Dowgate, and also for lime-burning, so that a sudden cold wind from the south-east filled the city with fog.

On 13th October, 1418, John Talworth and John Rephawe were sworn as Masters of the Misterie of the Woodmongers at Guildhall.

An old list of the Crafts of London, dated 9 Henry V. (1422), in the possession of the Brewers' Company, shews them 48th on the list, immediately between the Hurers and the Writers of Court Letters, and Strype tells us this was their position at the dinner to King Henry VIII. in 1532, to which they sent two representatives who wore no livery.

Furthermore, at the Court of Aldermen holden 8 July, 1518, to settle the number of Bowmen each Company should send to follow the Lord Mayor to keep the watch on the vigils of St. John and St. Peter, it was settled the Woodmongers should send two bowmen, the same number as the Cordwainers and eleven other lesser Companies.

Their first known Hall appears to have stood on the south side of Heralds' College, facing both St. Bennet's Hill and St. Peter's Hill, a short distance above the wood wharves at Paul's Wharf. (Queen Victoria Street now runs across this site.)

In 1544 they disposed of these premises and took a lease from Lord Audley of the refectory of the dissolved Priory of Holy Trinity, Aldgate.

This Priory formerly had an altar dedicated to St. John the Baptist, and as he was the patron saint of the Woodmongers and for centuries a wood market had been held outside the Aldgate in Portsoken, it is probable the altar was given by the Woodmongers.

When the Chapter House, which had been turned into the Church of St. James, collapsed, the congregation had service in Woodmongers' Hall.

In 1603 the Duke of Norfolk sold the whole place to the City of London, who having new ideas as to the development of the site, terminated the Woodmongers' tenancy.

The fratry was 70ft. by 34ft., with kitchens and offices adjoining, now covered by the Duke Street Synagogue.

Acts of Parliament, regulating the assize of wood and coals, were made in the reigns of Henry V., Edward IV., Henry VIII. and in 7 Edward VI.

On 11th October, 1580, the Court of Aldermen put under the rule and guidance of the Company all the cars and carmen of the City, and in the State Papers of 24th October, 1584, is a statement of the ancient order the Lord Mayor and Aldermen have taken for Woodmongers and of the provision of wood for London. Henry VIII. had formed the carmen into a fraternity to do away with the inconvenient right of purveyance within the City of London, and Queen Elizabeth fixed the number of carts at 400, of which 100 were to stand in Southwark, 100 on the woodwharves and 200 in Cheapside and in the outer regions of the City, each cart paying a yearly rent to Christ's Hospital.

With the accession of King James came an era of the strengthening and creation of trading companies.

The Woodmongers used the opportunity to good advantage, and on 29th August, 1605, obtained a Charter of Incorporation from the King, which confirmed all their previous privileges and placed the carmen definitely under their rule and guidance.

What weighed largely with the King was their subscription of £200 towards his fund for creating the Ulster Plantation.

They then erected a large new Hall on the river side to the east of Paul's Wharf Hill, and on 1st October, 1605, received a Grant of Arms, Thomas Hunt being the first Master and Mark Snelling and Cuthbert Coleman the Wardens.

In 1550 twenty-two ships per annum

sufficed for the supply of coal to London, but by 1615 two hundred were necessary.

The carmen were never satisfied with being amalgamated with the Woodmongers, but it took them a long time and many legal cases before they got free again.

Cromwell referred their petition to the Committee for Trade, but nothing came of it.

At the Restoration, Sir Richard Brown, the Lord Mayor who received back Charles II., happened to be a Woodmonger, and soon got all their privileges confirmed under a lease for 61 years, they giving a bond for £1,000 to Christ's Hospital.

One of the privileges granted the Grenadier Guards at the Restoration was the right to act as coal heavers in their spare time, coal-heaving being an arduous occupation requiring lusty men, and a four-hour day being sufficient for most men.

All know the famous marching song of the Guards, the British Grenadiers, and some have no doubt wondered what a tow-row, tow-row meant. The explanation is as follows :—

A gang of coal heavers consisted of 16 men, who heaved the coal up by stages from the hold and a foreman who turned the basket into the vat. Each gang had their rendezvous at a particular ale-house, and the publican, to ensure the master of a ship asking for his particular gang, would promise him a gallon of rum if he did so. This was called the tow-row. If the gang worked well and cleared the ship rapidly the master would pass the rum on to them. Hence the tow-row for the British Grenadiers.

The nick-name of the Coal Heavers still sticks to the Grenadier Guards in the Army. Four years later complaints anent the Woodmongers were rife again, and on 14th January, 1664, the House of Commons appointed a Committee to inspect the laws regulating the sale of wood, coals and other fuel, and to treat with the Lord Mayor and examine grievances concerning retailers enhancing the prices of coals.

On 2nd March an Act was passed regulating the Assize and Measure of Wood and Coals. The minutes of the Court of Common Council tell us a lot about the proceedings, and there are long petitions both from the Carmen and the Woodmongers.

On 17th February, 1664-5, the Woodmongers handed back their lease for 61 years, receiving a cancellation of their bond, and an Act of Common Council, 21st June, 1665, took away their government of the cars and carmen, and ordered sea coals to be sold only in sea coal meter's sacks and prohibiting the Woodmongers from keeping any carts of their own, but compelling them to use the public cars.

The City Companies were ordered to store in their halls a quantity of coal in the summer to be sold cheap to the poor in winter, the quantity varying from 672 chaldron (25½ cwt.) in the case of the Mercers to as low as three chaldron in that of the Bowyers and Fletchers.

Whatever happened in the case of the small men, the Woodmongers in a large way continued to employ their own carts and ignored the Order of the Common Council.

All through the Plague their carts added to their usual duties the unpleasant one of carting away the dead. Sir Edmund Bury Godfrey, the Woodmonger of Westminster, was particularly active in this, and was eventually knighted by the King for his brave efforts.

Large public fires of coal were burned in the principal streets, because the doctors said this helped to clear the air of infection. About 200 chaldron a week were burned in this way.

The fleet of colliers was kept back at Deptford, and the woodmongers had to send their lighters down there to fetch the coal.

Then came the Great Fire of London, and the Woodmongers' Hall was utterly consumed, together with 20 wharves of wood and coals, value £20,000, and carts and gear. The Woodmongers were so busy salving the goods of others, charging as much as £40 for a cart, that they appear to have neglected looking after their own property until too late.

To add to the trouble, the country was at war with the Dutch, and the winter of 1666 was the most severe ever known.

On 8th December, Pepys writes: "In much fear of ill news of our colliers, a fleet of two hundred sail and fourteen Dutch men of war between them and us and they coming home with small convoy and the City in great want, coals being at three guineas per chaldron." And again in March, 1667: "Everybody now complains of the dearness of coals, being at £4 per chaldron, the weather being most bitter cold, so that the King said to-day it was the coldest day he ever knew in England."

Sir Edmund Bury Godfrey had been extremely busy trying to subdue the Great

Fire and the King presented him with a special silver cup in recognition of his efforts. When the weather grew milder things became somewhat better, for in April, 1667, Pepys writes: "To-day I got in some coals at 23*s*. per chaldron, a good hearing I thank God, having not been put to buy coal all this dear time, that during the war poor people have been forced to give 45*s*. and 50*s*. and £3."

However, the war continued, and with it the troubles of the Woodmongers. In the Domestic Papers, 5th July, 1667, we find: "Arrival of 60 sail of colliers; 200 more sailed with them without convoy, but have put into Llynn. The coals will be carried from Llynn to London. The price is 30*s*., the chaldron, water carriage to Cambridge will be 4*s*., cartage thence to Ware 20*s*., or 25*s*., water carriage, Ware to London, 6*s*. or 7*s*. per chaldron."

As usual the public were quite unable to realize the troubles of the coal merchant. All they knew was that coal was extremely dear and they threw all the blame on the Woodmongers and demanded a public enquiry, which was duly held.

Mr. Pepys, cousin of the diarist, formed one of the investigating committee who reported that the principal cause of the present extraordinary price of sea coals was the want of a sufficient convoy last summer to guard the colliers, and the pressing of their able seamen. They, therefore, recommended the Crown to grant protection to the seamen.

The report was adopted by the House by 69 votes to 47.

On 14th October, 1667, a Bill was introduced to prevent extortion and abuse in the sale of coal and wood, and was referred to a Committee instructed to send for the Patent of the Woodmongers and consider the laws in force against them and provide for the effectual putting of them in execution.

However, the Woodmongers appear to have been truculent, so the Clerk was ordered to be sent for in the custody of the Sergeant-at-Arms and the Master to attend the House to-morrow with the Charter and books of the Company.

The Master duly appeared with his petition, but on 6th November judgment was given: "It is resolved that this House do agree with the Committee that the Charter incorporating the Woodmongers with the Carmen is illegal. That the said Charter is a grievance to His Majesty's people and not to be continued. That coals and wood should be sold at easy rates."

Consequently, on 5th December, 1667, Sir Edmund Berry Godfrey, the Master, and Francis Baleb and Wm. Maibrin, the Wardens, surrendered the Charter before Sir Walter Littleton, Master in Chancery, the record being duly made in Latin of a very doggy nature.

Woodmongers' Hall was not rebuilt after the fire, as it was settled to have a broad quay, 40 feet wide, all the way from the Tower to the Temple, raised three feet to avoid inundation, and pushed out some way into the river. (In fact, this open quay existed for 100 years, and not until the 19th century did folk dare to encroach on it with cranes, sheds and houses, the City winking a blind eye, and Parliament, in 1821, ill-advisedly passing a short Act exonerating the offenders.)

It had been a very ancient location for the trade in wood for as early as 29 Edward I. St. Bennet's is called St. Benedict del Wodewharf, and in 14 Edward II. we come across the Wodehawe there.

The disputed cases as to tenures, which for 10 years after the fire engaged the attention of the judges, contain nothing concerning the Woodmongers' Company, although there are two cases referring to individual woodmongers in Thames Street and on Puddle Dock Hill.

Where the Woodmongers held their Hall after this is not clear. My own idea is they had rooms near the Dog Tavern, opposite the Customs House. There is nothing in Oliver and Mills' survey.

In the Additional Building Act, the Lords tried to insert a clause that the sites of St. Magnus the Martyr, St. Botolph, Billingsgate, St. Michael, Queenhithe, and All Hallows the Great and Less, should be converted into public store-yards for coal and other fuel, but this was not accepted.

Sir Christopher Wren, in his plan for rebuilding London, wisely provided for a great wood wharf to the east of the junction of the Fleet with the Thames, with a site for their Hall next Bridewell Dock. But the City, in their wisdom, bearing in mind that the site for the coal trade from the earliest times had been higher up the Fleet next Sea Coal Lane, which is mentioned in the Pipe Rolls as early as 1228, determined to canalise the Fleet at a cost of £80,352, and erect large coal vaults along

it with a large hollow square to the east entered from Sea Coal Lane, in which the carts could comfortably stand. These survived until 1734, when the river from Holborn Bridge to Fleet Bridge was arched over and the Fleet Market House erected over it by George Dance the elder, the remainder of the Fleet remaining open until 1765.

But the City were wrong in expecting it to become the chief centre of the trade. Only the smaller merchants went there, as boats could only come up at high tide, and even then had to pass three bridges. The larger merchants preferred to be in the River Thames. There was a coal meters office in Durham House Yard, where the premises of the Royal Society of Arts now are, and woodwharves between Somerset House and Arundel House Garden and at the foot of Milford Lane, and also at the foot of Water Lane.

A clause was added to the Act for rebuilding the City, raising the coal tax to 1*s*. per chaldron, but the trade was so disorganised that this produced but a small increase, so in 1670 it was boldly raised to 3*s*. per chaldron.

It was coal which paid for the straightening and widening of the streets, for levelling the contours, erecting the wharves, canalising the Fleet, for markets, Bridewell and other prisons, for all the Wren city churches, even for St. Paul's Cathedral, all of which money passed through the hands of the Woodmongers, who, in spite of the surrender of their Charter, remained a powerful body. The City dues were raised to 1*s*. 2*d*. per chaldron in 1687 and so remained until 1831, when they were reduced to 1*s*. 1*d*. per ton. In those days 136 Newcastle chaldrons equalled 217 of London.

Pepys tells us that in May, 1669, Sir Edmund Berry Godfrey dared to arrest for a debt for coals the King's physician, Sir Alexander Frazer, within the royal precincts of Whitehall, which made the King so angry he had the bailiffs severely whipped and put in prison in the Porter's Lodge, where he also imprisoned the worthy knight, who, however, went on hunger strike, and had to be released.

In 1673 a Bill was introduced into Parliament for the better regulation of the coal trade, but Parliament was prorogued before it could be passed, so the King wrote and instructed the Lord Mayor to appoint a Committee with a view to an Act of Common Council being passed. They drew up their Order, but the Woodmongers refused to be bound by the rule they should have no carts of their own, and took the matter before the judges, where it hung about from Court to Court for years, until in 1679 the Court declared the Act was illegal and a monopoly.

The Woodmongers put forward many reasonable suggestions. Nevertheless, in October, 1680, the Committee for the Markets made a new Act, fixing the total number of carts for the City as 420 and putting them all under the oversight and government of Christ's Hospital, the arms of the City to be on the shaft of each cart, and refusing any carts to the Woodmongers who, when they sold coal, were to be compelled to send for a public cart and send along with it a sealed bushel for measuring the coals if need be, which might only be sent in sea coal meters sacks.

Meanwhile, the Woodmongers had been in the limelight, for in September, 1678, Titus Oates brought to Sir Edmund Berry Godfrey his narrative of the Popish Plot. Six weeks later the worthy knight disappeared and was found murdered on Primrose Hill. Medals were struck, showing the murder. Three men were tried and hanged at Tyburn. Samuel Pepys' servant, Samuel Atkins, was accused of being an accessory before the act, but was acquitted, Pepys himself writing out his defence.

The Woodmongers stuck to their ideas, and in 1681 the judges gave directions how the Act should be amended. The Carmen, who had formed themselves again into a fraternity (which still exists and led off the last Lord Mayor's Show) with three Wardens and 20 Assistants, a Clerk and a Beadle, offered in addition to the £400 payable annually to Christ's Hospital, to pay £400 to the City and to make and maintain a cartway up and down Tower Dock if they were left with a monopoly.

For 13 years more the controversy dragged on, until in October, 1694, the City passed a fresh Act, allowing the Woodmongers 120 carts of their own, to be used only for carrying coal and fuel, to be burned with a faggot mark on both sides, and the raves of the carts to be higher than those of the street carts the better to distinguish them and to keep the coal from falling off. This type of cart continued in use up to 1865, when the present type of van was invented.

A list of such carts and their owners

was to be made each year in May for the Lord Mayor and Aldermen.

Thus the Woodmongers once more came into their own.

In 1694 the metage was raised from 4*d.* to 8*d.* per chaldron, and Orphans' Dues of 6*d.* per chaldron were created, which were not liquidated until 1782, and continued as the coal dues to our own era, being utilised for City improvements.

The Woodmongers' triumph was short-lived. Six years later a much more dangerous event occurred.

On 29th September, 1700, an Act of Parliament was passed which amalgamated the Watermen and Lightermen into one large Company and prohibited any but those registered by the Company from working boats on the Thames.

The Company promptly started to oppress the Woodmongers by refusing to register them as Lightermen, which led to a petition being sent to Parliament, but the evil practices continued, until in 1730 they led to a series of petitions and broadsides and to an enquiry which resulted in a new Act, empowering all persons having wharves for the sale of coal to keep and employ their own lighters, but to enter them on the books of the Watermen's Company and to employ properly qualified men registered at Watermen's Hall. Twelve Lightermen then handled half the coal coming to London, 40 others handling the other half.

In January, 1740, the Thames was frozen over and coal rose to £3 10*s.* per chaldron.

Orphans' Dues were given an extension in 1748.

In 1758 the trade was greatly disturbed by the pressing of men for the Navy, 800 being impressed on 22nd June.

By that date the Woodmongers' Company would appear to have died of inanition. Many of its members and their sons being freemen of the Watermen's Company, no longer saw any necessity for belonging to another Company. Yet the Watermen's Company embraced many others who were not interested in coal.

To get over this difficulty and to unite both parties, the Society of Coal Merchants would appear to have been created in 1731, which took over as an inheritance the duties of the Woodmongers' Company.

As to the date when the last Freeman of the Company was admitted I cannot say, but the title still persisted, and as late as the enquiry of 1830, we find a witness declaring he was a Woodmonger, but his son was a Lighterman and had served seven years to the oar.

In May, 1758, we find the Coal Heavers petitioning Parliament anent the Coal Undertakers, a class of men who had created their own Labour Bureau and had purchased a monopoly of the coal shovels, which they purchased at 3*s.* 6*d.* each and hired out at 1*s.* the time.

The House appointed a Committee to investigate, and on one of the Undertakers threatening a Coal Heaver ordered him to appear on his bended knees at the Bar of the House.

An Act was passed in June, 1758, for the better regulation of the Coal Heavers and to enable them to create a Benevolent Association.

In 1763 the Thames again froze and coal rose to £2 15*s.* per chaldron.

In 1767 Orphans' Dues were again extended, and the Coal Merchants obtained an Act to establish Land Meters and make a charge for the measuring into sacks from the barges between the Tower and Limehouse Hole. The harvest failed the same year and the cost of living rose accordingly, and led to grave riots among the Coal Heavers, which, coupled with Wilkes and Liberty, resulted in the St. George's riots terrorising London in the following April, May and June, until the military were called out, and eventually two of the culprits were hung at Tyburn and seven more in Sun Tavern Fields. The rioters were largely Irishmen. They put in another petition to Parliament the following March, blaming the Coal Undertakers again. In 1768 the Coal Exchange was erected in Lower Thames Street.

The Government tax on coal was steadily rising about this time, being 8*s.* per chaldron in 1775, and 9*s.* 4*d.* in 1798.

Up to 1786 the Coal Heavers worked in gangs of 16, with a master, but a new system was then introduced by which the coal, instead of being shovelled up by stages to the vat, was whipped up whippers in a basket and the gang reduced to eight men, four of whom shovelled while four whipped the basket up by ropes on a pulley, and the foreman as basket man turned the basket over into the vat. This was a great improvement.

In 1788 an Act was passed prohibiting any number of persons exceeding five from uniting for the purchase of coal.

In 1786 the Coal Buyers Indemnity Act had relieved the merchants from the responsibility for weight and put it on the Land Meters, who had started first of all in Westminster and been introduced into London in 1734, and who were on duty from 5 a.m. to 9 p.m., with no recognised breaks for meals.

In 1797 the Expedition to Holland took away a large number of the ships and upset the coal trade with the usual results and outcry. An enquiry was held in the Lords, followed in 1800 before a Committee of the Commons, on which sat Mr. Pitt, Mr. Wilberforce, Sir Matthew White Ridley, the Lord Mayor and others.

As a result it was decided to buy out for £25,600 the Coal Exchange, which had been erected privately in 1768 in Lower Thames Street, to charge every ship arriving with coals a penny per chaldron to pay for the purchase, to throw the Exchange and Trade open to everyone and put it under the care of a Committee of the City, presided over by an Alderman.

The individual societies of factors and merchants and the privileges of the Watermen, nevertheless, continued to exist.

In 1805 an Act was passed enabling coal to be brought to London by the Grand Junction and Paddington Canals up to 50,000 tons a year, paying 1*s*. 2*d*. per ton duty plus the market penny.

In August, 1807, there was a fresh Act of Parliament, by which nine coals only were allowed to be sold as Best Coals, but might be mixed, and three sorts were allowed to be mixed and sold as one or the other, but no other coals might be mixed, and compelling all coals ex-ship to be sold on the market only, 21 chaldron to be the minimum sale there. A fine of £20 per chaldron was imposed for selling one coal in place of another. No man was allowed to act as a Coal Undertaker without a licence from the Corporation, and no licensed victualler to be a Coal Undertaker. Shovels and baskets were to be found by the ship's master. The Undertaker was to be allowed 1*d*. per chaldron.

In 1807 the old Act empowering the Court of Aldermen to fix the price of coal was repealed, and in 1809 the Government tax was raised to 12*s*. 6*d*. per chaldron, and so continued to 1815, when it was reduced to 9*s*. 4*d*.

The system of the Ingrain, by which the colliery owner gave 21 chaldron and charged it as 20 (the score) applied to the south only, the ship owner reckoning freight on the same basis. Suffolk, Essex, Middlesex, Surrey and Kent were the counties affected. A purchaser of 5 chaldron had the ingrain passed on to him. Smaller purchasers had an adjustment made in the price. Its origin very likely came from an attempt to compensate the customer for the payment of the coal dues, coupled with the knowledge that coal was lost in loading and unloading the ship and loss from slates.

In 1827 6,883 ships came to London with coal, averaging about 300 tons each.

In 1814 only 2,707 chaldron were coming by canal.

In 1824 the Government tax was reduced to 6*s*. the chaldron, and in the next three years the price of coal fell from 46*s*. to 36*s*. 6*d*.

In 1827 the coal merchants and others were writing to Parliament, complaining of the very unsatisfactory nature of the coal meters, and also about the Coal Tax.

This eventually led to a general enquiry into the whole trade, first before the Lords and then before the Commons.

The evidence given very clearly shows the manner in which the trade was conducted. Thus, Wm. Horne said he employed four horse wains carrying 2½ chaldron at a time. If anyone ordered 2½ chaldron or more they got the ingrain, if less an adjustment was made in the price. All cartage was averaged and charged at 6*s*. per chaldron plus 1*s*. 6*d*. per chaldron for shooting the coal and 1*s*. per five chaldron for trimming.

The carmen did 8¾ chaldron per day. He only paid one man, but two always went with the wain, and sometimes they took a third. The wages were 9*s*. per week for driving and attending the horses and 9*d*. per chaldron for the coal. The average cartage was 1½ miles and the charge made was for deliveries "on the stones," extra being charged on bad roads.

The carmen did an average of 3½ journeys a day over the year of 300 days.

The loaders were paid 1*s*. per chaldron and worked in gangs of five, of whom three shovelled and two stowed the sacks, the carmen paying them 3*d*. per chaldron for the stowing. The loaders earned 7*s*. to 8*s*. per day and the carmen's wages worked out at 6*s*. 9½*d*. per day.

The merchants generally took a day off on Thursdays.

Their profit on sales was very moderate.

being about £1 on 52 chaldron, and they reckoned to make their real profits out of their discounts and ingrain and on working their barges and cartage well.

Where credit extended over more than two months they charged 2*s*. per chaldron extra. Bills were usually paid once a year. Wages had advanced in 1810 owing to the high cost of provisions, but were reduced again in 1824 and were now overdue for a further reduction.

There were 19 houses of coal factors and 10 of first buyers who took the whole contents of a ship and who sold to the second buyers, representing some 60 other firms, at 1*s*. per chaldron commission. A first coal buyer would have room for some 2,000 chaldron on his wharf.

The result of the enquiry was an Act of Parliament which revolutionised the coal trade.

Sea coal meters were done away with for seven years and land meters were abolished.

Coal was to be sold by weight and not by measure.

A customer was to be allowed to make the carman weigh the whole load instead of one sack in the presence of a police constable, and the merchant was robbed of his right of being notified before the weighing took place.

The poor lost their right of receiving the coal which henceforth was not to be forfeited.

Coal must be delivered in sacks, each containing 1 cwt. or 2 cwt. or else in bulk.

The Government tax of 6*s*. was entirely abolished.

The City dues were altered from 1*s*. 2*d*. per chaldron to 1*s*. per ton plus 1*d*. for the expenses of the Coal Exchange.

Any Lighterman might enter into partnership with any Woodmonger solely for trade in coal.

The Act, of course, entirely disorganised the trade. Those in the trade felt it very awkward, there was no independent person to judge between buyer and seller. Consequently the Society of Coal Factors and the Society of Owners of Coal Craft subscribed money between them for a Coal Meters' Society, under a deed of trust, and engaged a clerk to license meters, the City Authorities lending their late clerk to instruct him in his duties, with a Committee formed half of factors and half of merchants, with a different President every month. It was so efficient and simple that the City never resumed its duties, and the Society of Owners of Coal Craft having changed its style to the Society of Coal Merchants in 1836, the latter Society finds the members of half the Committee, which are now reduced to six aside. Both parties pledged themselves to employ only meters licensed by the Clerk.

When the enquiry into the City Companies was held 1826-1828, a summons was sent to the Woodmongers, but no one appeared.

Acts of Parliament for long after continued to style Coal Merchants as Woodmongers, however.

OBITUARY.

SIR LANCELOT HARE, K.C.S.I., C.I.E.—Sir Lancelot Hare, a distinguished Indian Administrator and Lieutenant-Governor of Eastern Bengal and Assam, from 1906 to 1911, died on October 7th at his residence in Embankment Gardens, Chelsea. Born in 1851 he was a son of Thomas Hare, Bencher of the Inner Temple, political reformer, and father of Proportional Representation. He was educated at St. John's College, Hurstpierpoint, and the City of London School. He passed the Indian Civil Service Examination of 1871 and was posted to Bengal, where, after the usual period of probation, he arrived, in 1873, during Sir George Campbell's governorship. Among the posts he successively filled were those of Officiating Inspector-General of Police, Assam (1880), Commissioner of Patna (1900), and Chief Secretary to the Bengal Government (1903). In 1904, upon the nomination of the late Sir A. H. L. Fraser, he became a member of the Bengal Board of Revenue—one of the coveted prizes of the Service—and was also given a seat in the Provincial Legislative Council. In 1906, while acting as Lieutenant-Governor of Bengal in Sir A. Fraser's absence on leave, he was chosen to succeed Sir Bampfylde Fuller as head of the administration in the newly-created Province of Eastern Bengal and Assam. Throughout his term of office as Lieutenant-Governor he was beset by very formidable difficulties arising from the extreme unpopularity of "partition," or, as Lord George Hamilton described it at the Royal Society of Arts when Sir James Bourdillon read a paper on the subject, "The duplication of administrative machinery."

Sir Lancelot joined the Society twenty-two years ago and was actively interested in the work of the Indian Section, attending most of its meetings and sometimes taking part in the discussions. Economics attracted him and he

was one of the speakers at the Sixteenth Ordinary Meeting on March 15th last, when Mr. Oswald T. Falk, C.B.E., read his paper on the problem of exchange stabilisation. Sir Lancelot had himself a few months earlier written a work entitled "A Study of Exchange." He was also the author of a pamphlet on "The Transferable Vote System."

INDUSTRIAL CONDITIONS IN NORWAY.

Norway is in some respects one of the most interesting countries in Europe. The area round Christiania is the most highly industrialised. But the conditions in the west of Norway are quite exceptional by reason of the small and scattered population, and the broken and mountainous country rendering communication difficult. With its long coastline it has naturally great maritime interests. Prior to the war Norway stood fourth amongst the countries of the world in respect of mercantile marine, with a total tonnage of about 2,600,000. The proportion born by its commercial fleet to population was higher than that of any other country. Nearly half the shipping was destroyed during the war, yet by 1921 it had already attained its former value.

As is well known, there are great fishing centres off the western coast, notably at the Lofoden Islands. In good years the total value of the fishery products has reached £5,500,000. The fish market in Bergen is a famous sight for visitors, but generally speaking, not much is seen of this activity by the tourist who visits this part. He is more concerned with the pastoral life of the people in the fiords, whose livelihood depends mainly on their cattle, and especially their famous and varied kinds of cheese. Every visitor to Norway is aware of the scanty growth of grass at the foot of the cliffs, which has led to the practice of sending the cattle up to "saeters" a thousand or more feet up, where they can feed on the upper grass, whilst that in the valley is cut and stored for the winter.

The next impression received by visitors is the marvellous growth of trees in the humid Norwegian climate, often growing out of imperceptible crevices in the rock lining the fiords. Houses are invariably constructed of wood, and in their fresh coats of paint make a charming sight perched at intervals up the steep hills. There is said to be upwards of 26,640 square miles of forest area in Norway, about 60% being pine and fir. Exports of forest products have reached £8,000,000 in some years, an important element being the supplies of wood pulp. The Norwegian Afforestation Association is responsible for the upkeep of these forests, 10 to 15 million trees being planted annually.

A third consideration of interest is the general use of electricity. Norway has no coal of its own and derives about 25% of her imports of this commodity from Spitzbergen. The cost is naturally high. Fortunately, the country is unique in its abundant and conveniently situated water power, from which electricity is almost exclusively obtained. The potential water power has been estimated at 15 million h.p., of which the State owns about two million. The great advance in the use of electricity is illustrated by the fact that in 1907 only 250,000 h.p. had been developed, while by 1913 the figure had risen to 750,000 h.p., and by 1920 to 1,200,000 h.p. This development of electric power has had a marvellous influence on the industries of Norway, bringing into existence new sources of revenue. The position of local industries is often decided by the site of electrical generating stations, situated in delightful surroundings amidst the hills, and without any of the smoke and refuse which one associates with stations in England. Hydro-electric developments have led naturally to the initiation of carbide, aluminium and artificial nitrate works. Norway is not a rich mining country, most of the ore being of relatively poor grade. But electrical smelting will make possible the treatment *in situ* of ores which would otherwise be exported in the crude state, or possibly would not pay for development. A scheme is now on foot for supplying electric power to Denmark, and possibly ultimately to Germany. Electrically driven flour and textile mills, each with its colony of picturesque wooden cottages for workers, are found in most unexpected places.

Yet another form of local industry in which Norway excels is the production of hand-woven mats and carpets, work on which is undertaken mainly in the winter months when there are no English visitors to distract attention. At the Hotel Mundal, at Fjaerland, where the greatest glaciers in Europe descend from the Jostedal snowfield to the foot of the fiord, there is a workshop of this kind. Here some delightful work is done under the supervision of Brita Mundal.

Few people realise the small population of Norway—little more than 2½ million people. The population of Christiania, its capital, is only about a quarter of a million, and of Bergen, the next biggest town, about 90,000. Norwegians, however small in number, are an industrious race with varied interests, friendly and hospitable disposition and a general resemblance to the British, for whom they have a traditional liking. The blending of pastoral life and industry is one of the happiest features of Norway. English is a compulsory subject in the schools, with the result that things are made easy for the British visitor. It is interesting to recall that the leading travel bureau for Norway is associated with the name of an Englishman, Bennett, who has thus been the means of introducing many of his countrymen to the delights of Norwegian scenery.

J. S. D.

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FRIDAY, OCTOBER 27, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

OPENING OF THE 169th SESSION.

The opening meeting of the 169th Session will be held on Wednesday, November 8th, when an address will be delivered by LORD ASKWITH, K.C.B., D.C.L., Chairman of the Council, on "The Value of Strikes and Lock-outs." The Chair will be taken at 8 p.m.

ARRANGEMENTS FOR SESSION 1922-23.

Particulars of the arrangements for the forthcoming session, so far as they are at present completed, are in course of issue to all Fellows of the Society.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

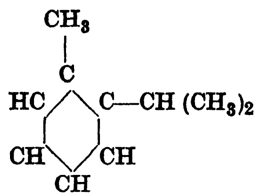
THE CONSTITUENTS OF ESSENTIAL OILS.

By LIONEL GUY RADCLIFFE, M.Sc.Tech., F.I.C.

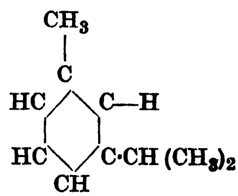
LECTURE II.—*Delivered March 27th*, 1922.

THE CLASSIFICATION OF THE CONSTITUENTS OF ESSENTIAL OILS.

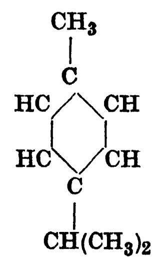
In general essential oils may be regarded as consisting of two main ingredients—the first of these is a terpene or a mixture of terpenes, whilst the other ingredient is a more or less complex mixture of other chemical compounds, and the individual members of this mixture may include any of the more common classes known to organic chemistry. In some oils the terpene is the most important component, but this is seldom the case when the main use of the essential oil is on account of its characteristic odour. The terpenes are compounds composed of carbon and hydrogen only, and this term was first given to them by Kekulé, and he also showed the relationship between the hydrocarbon cymene (methyl para isopropyl, benzene) and the terpenes as a group. Of the oils in which terpenes predominate, the best known is the familiar liquid turpentine, and Kekulé by treating this with iodine obtained the fundamental hydrocarbon cymene. There are the usual three isomeric forms of cymene :—



ortho cymene



meta cymene



para cymene

and from these cymenes most of the various terpenes can be obtained. Cymenes are to be regarded as the parent substances of the terpenes, with the exception of certain terpenes of which pinene, camphene and fenchene are the chief. Para cymene is the most important one of the three, giving rise to such terpenes as limonene, dipentene and terpinolene, whilst meta cymene is the parent substance of sylvestrene and carvestrene.

To understand these relationships it must be borne in mind that those hydrocarbons which have the empirical formula C_5H_8 are termed terpenes, and of these there are four main classes :—

Hemiterpenes C_5H_8.
Terpenes proper $C_{10}H_{16}$.
Sesquiterpenes $C_{15}H_{24}$.
Polyterpenes $(C_5H_8)n$.

The terpenes proper and sesquiterpenes form the most important members of their class which occur in essential oils. Actually in such oils several different terpenes often occur together, and in addition the oils frequently contain oxidised compounds, which in many cases are not separable from the terpenes by fractional distillation or only an exceedingly imperfect separation can be effected. This difficulty as to the separation was in the past an exceedingly important matter and made the sharp characterisation of the individual terpenes an impossible task until chemical methods were discovered which enabled the individuals to be isolated in a chemically pure condition. Up to this time all sorts of mixtures had been given special names under the supposition that they were individual terpenes and the result was utter confusion.

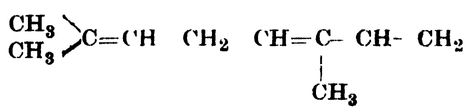
Before dealing with the terpenes proper, it is necessary to say a few words about the other hydrocarbons which occur in essential oils, as certain of these are of considerable importance, for example :—Normal heptane $CH_3{\cdot}(CH_2)_5{\cdot}CH_3$ belonging to the paraffin series is found in the oil of digger's pine (Pinus Sabiniana), it is a liquid having a gravity of about 0·700. When certain essential oils are evaporated they leave behind wax-like solids belonging to the hydrocarbon waxes, and the following oils yield such products :—Arnica flowers, bergamot, caraway, chamomile, dill, neroli, sassafras and wintergreen. The wax-like deposit left on evaporating the oil of bergamot is in reality a mixture, and of considerable interest in the chemical examination of this oil; further, the unsaturated hydrocarbons, octylene and nonylene have been found, the former in oils of lemon and bergamot, and the latter in oil of lignaloe.

There is an interesting hydrocarbon which may be classified as a hemiterpene, viz., isoprene $CH_3{-}\underset{\underset{CH_2}{\|}}{C}{-}CH{=}CH_2$ though it has not been found in any essential oil, yet it stands closely related to the terpenes and can be easily changed into the true terpene, dipentene. It is a highly unstable liquid produced by the destructive distillation of rubber and is of paramount importance in connection with rubber and gutta-percha.

THE ALIPHATIC OR OLEFINIC TERPENES.

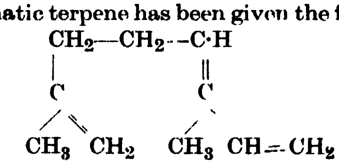
These are hydrocarbons, having their carbon atoms arranged in open chains and are not really true terpenes. They are characterised by the ease with which they oxidise and resinify and by their low specific gravity and low refractive index.

Myrcene occurs in two forms, one of which was discovered by Power and Kleber in oil of bay leaves and oil of sassafras leaves; it is a liquid having a specific gravity of 0·802, and a boiling point of 67° C under 20 mm. pressure, whilst its very low refractive index of 1·4673 is an indication that it contains three double linkages, and this is shown by the formula deduced by Enklaar in 1906:

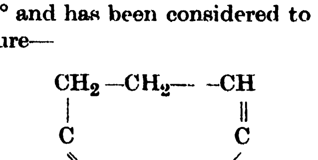


Ostromisslenski and Koschelev, 1915, produced a synthetic terpene by heating isoprene to 80°-90°, and this they consider to be β—myrcene $C_{10}\ H_{16}$.

Ocimene was discovered in the oil from the leaves of Ocimum basilicum, it has a specific gravity of 0·801 to 0·803, boils at 172° and has a refractive index of 1.4857. This aliphatic terpene has been given the formula:



It is unstable and on heating is converted into an isomeride allo-ocimene, which boils at 188° and has been considered to have the structure—



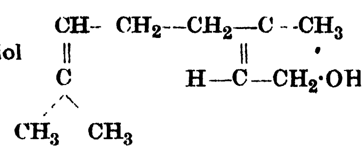
of the two, though both absorb oxygen, allo-ocimene is much the more easily oxidised.

The open chain structure is of the utmost importance in connection with a whole series of alcohols and aldehydes, every member of which is highly odorous and these will be dealt with before the terpenes proper and their derivative.

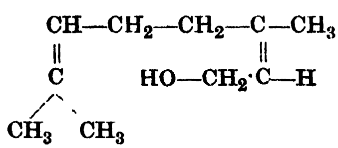
The aliphatic or olefinic terpene alcohols and aldehydes. The compounds to be dealt with exhibit amongst themselves a certain similarity of structure, and at the same time show a definite connection with the terpenes proper. The substances themselves occur in essential oils in large proportions and are responsible, in many cases, for the delicate and characteristic aroma of the oils in which they occur. Their chemical structure is such that they contain 10 carbon atoms arranged in such a way that 6 of these form a straight chain, 3 of the remainder are in the form of an unsaturated isopropyl group attached to one end of the chain, whilst the tenth remaining carbon atom is a methyl group attached to the fourth carbon atom from the end of the chain. Actually the grouping may be regarded as resembling that of a monocyclic terpene in which the ring has been broken, and this conception is not a purely fanciful or theoretical one, for cyclic terpene can be obtained by quite simple methods from these olefinic straight chain compounds, and by a reversal of the process several cyclic compounds may be converted into open chain members of the aliphatic terpene group.

TABLE.

Geraniol

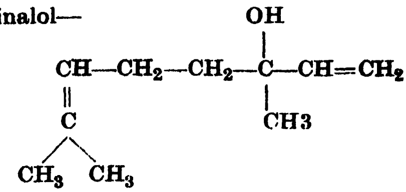


Nerol

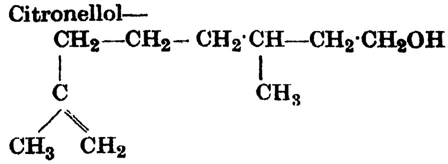


this is a stereo-isomer of geraniol and each of the two give aldehydes on oxidation.

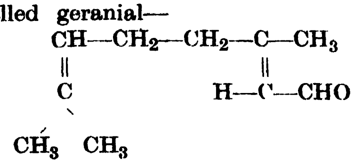
Linalol—



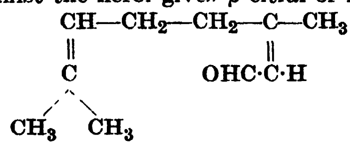
Citronellol—



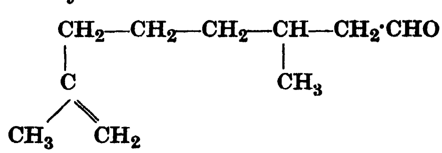
Geraniol when oxidised yields α citral, also called geranial—



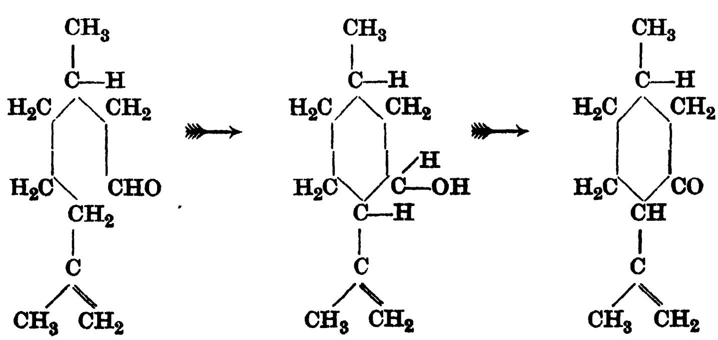
whilst the nerol gives β citral or neral—



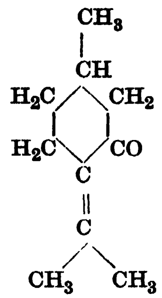
from citronellol there is obtained the aldehyde citronellal—



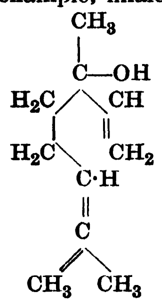
The relationship of the above compounds to the terpenes can be shown as follows:—When citronellal is heated with acetic anhydride it changes into the alcohol isopulegol and this on oxidation becomes isopulegone—



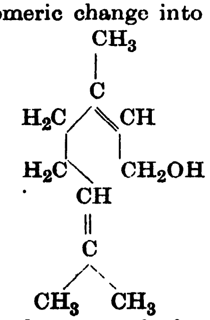
The resulting isopulegone when treated with baryta water, undergoes an isomeric change into pulegone:—



As another example, linalol:—

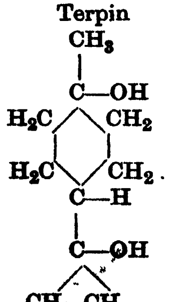


treated with formic acid yields a mixture of terpin and dipentene. In the first place, it appears probable that the linalol undergoes an isomeric change into geraniol—

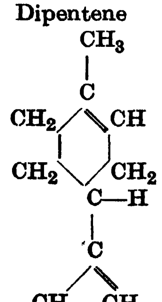


and this, by the removal of water from one part of its formula, and the subsequent addition of the elements of water to another part of its structure gives, as a first result, ring formation and terpin, from which a loss of water results in dipentene:—

Terpin

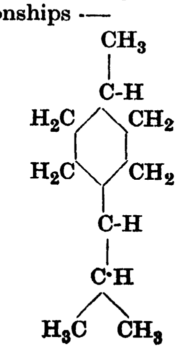


Dipentene

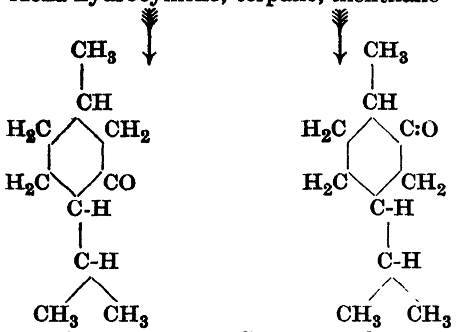


This brief outline will be sufficient for the comprehension of the relationships of the aliphatic terpene derivatives. In addition to the aliphatic terpenes there are also the aliphatic sesquiterpenes and their derivatives, of which a brief mention must be made. Sesqui-citronellene $C_{15}H_{24}$, is an example of an aliphatic sesquiterpene with two conjugated double bonds and is isomeric with ocimene; it was isolated from Java citronella oil by Semmler and Spornitz. In 1904, Soden and Treff and Haarmann and Reimer discovered an aliphatic sesquiterpene alcohol called Farnesol, in various acacia oils, and otto of rose, musk seed oil, and lime blossom oil. There are corresponding aldedydes and acids, whilst "Doremone" is an aliphatic sesquiterpene ketone, discovered in oil of gum ammoniacum.

Returning now to the cyclic terpenes—the terpenes proper may be divided into two large groups in which the hydrocarbons of the first group contain one ethylene linkage, whilst those of the second group contain two such linkages. As a class, the terpenes may be regarded as hydro-cymenes, and though hexa hydrocymene does not occur in essential oils, there are oxygen containing compounds corresponding to it which are very widely distributed in nature, *e.g.*, oil of peppermint contains the alcohol menthol $C_{10}H_{19}OH$, and the ketone menthone $C_{10}H_{18}O$. Two compounds, carvo-menthone $C_{10}H_{18}O$ and carvo - menthol, (tetra - hydrocarveol) $C_{10}H_{19}OH$, structural isomerides of the other two, are to be considered as a completely hydrogenated parent substances of a considerable number of unsaturated oxygenated members of the terpene group, though they themselves have not been found in essential oils. If one molecule of water be eliminated from menthol or carvo-menthol, isomeric hydrocarbons of the formula $C_{10}H_{18}$ are formed which may be considered to be structural isomerides of tetra hydrocymene. The following table will illustrate these relationships:—

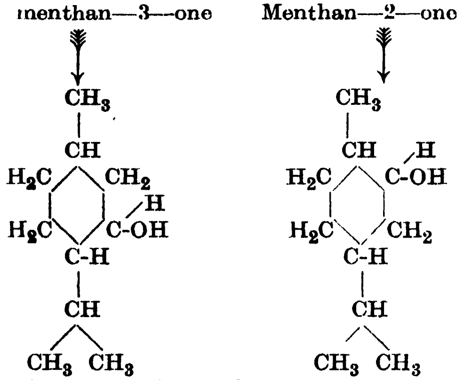


Hexa hydrocymene, terpane, menthane



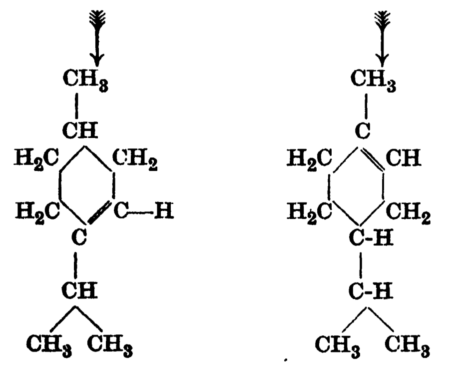
Menthone, and β.ketohexahydro-cymene
Terpan—3—one, menthan—3—one

Carvo-menthone and α.ketohexahydro-cymene
Terpan—2—one, Menthan—2—one



Menthol, and β.oxyhexahydro-cymene
Terpan—3—ol, Menthan—3—ol.

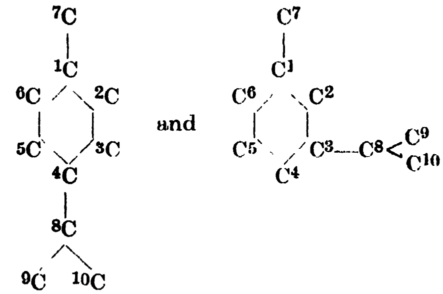
Carvo-menthol, and α.oxyhexahydro-cymene
Terpan—2—ol, Menthan—2—ol.



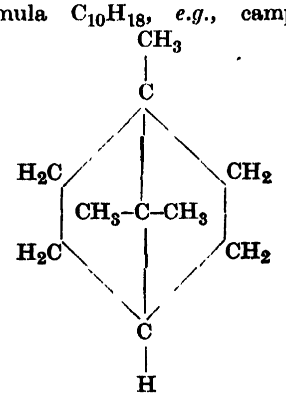
Menthene, Δ^3.Tetrahydrocymene, Δ^3-Terpene, Δ^3-Menthene

Carvo-menthene, Δ^1.Tetrahydrocymene, Δ^1-Terpene, Δ^1-1Menthene

In accordance with our present knowledge of the terpenes which is partly derived from their optical activity, molecular refraction and magnetic rotation, they may be separated into a monocyclic and a bicyclic group. The first group of monocyclic terpenes also called menthadienes, may be regarded as dihydro derivatives of para and meta cymene, or expressed in another way, as unsaturated derivatives of hexa hydrocymene, *i.e.*, menthane. For purposes of nomenclature, the latter view is adopted, and the members of the group are described as menthadienes, *i.e.*, menthane with two double linkages, and the positions of these linkages is indicated by the use of the Greek capital Δ, in conjunction with the usual method of numbering the benzene ring:—



The second group includes the bicyclic terpenes and shows, as a class, a characteristic behaviour when a member is submitted to certain chemical treatment, inasmuch as such terpenes can only unite with one molecule of a halogen or of a halide acid, and for this and other reasons, they are assumed to have what is called a "bridged ring" structure. These bridged rings are now recognised as the basis of the second group, and corresponding to such compounds are saturated hydrocarbons of the formula $C_{10}H_{18}$, *e.g.*, camphane



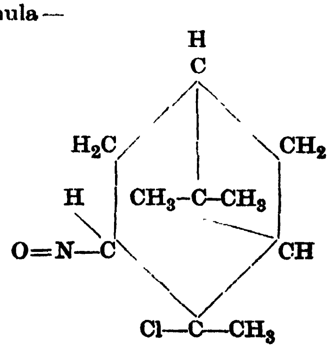
It has already been pointed out that all the terpenes are unsaturated compounds, but distinct differences are shown in the respective capabilities of different terpenes to combine with the halogen acids, and this

property is most useful for the recognition of the individual members. For example, the bicyclic terpene, pinene, which forms the major portion of oil of turpentine, on treatment with dry hydrocholoric gas in a freezing mixture yields a solid saturated compound—the result of the addition of one molecule of hydrochloric acid—the compound being called pinene mono-hydrochloride $C_{10}H_{16} \cdot HCl$; this is a camphor-like mass and has been called "artificial camphor," and can be crystallised from alcohol when it melts at 125° and is so stable that it distils almost unchanged between 207°-208°. If this hydrochloride is heated with aniline, the hydrochloric acid is removed and another terpene, camphene, is produced. This camphene can itself absorb a molecule of hydrochloric acid, and yields a similar mono-chloride which resembles that from pinene except that it melts at 151°, and there is also a difference in its stability. The monocyclic terpenes or menthadienes, dipentene and terpinene, combine with two molecules of hydrochloric acid, each yielding the same compound, a dihydrochloride $C_{10}H_{16}$ 2HCl, of which there are cis and trans varieties. Sylvestrene, which occurs in Swedish pine oil, is a terpene derived from meta cymene, and yields a dihydrochloride melting at 72°, whilst the purely synthetic terpene, carvestrene, also a meta compound, yields a dihydrochloride melting at 52°.

The addition of bromine to the various classes of terpenes gives rise to bromine addition compounds which play an important part in the recognition of the terpenes. In general, the reaction is conducted by brominating the terpene in nearly glacial acetic acid solution and then recrystallising the products from acetic ether. By this means the two large terpene groups are distinguished, the members of the first group containing one ethylene linkage are only able to add on one molecule of the halogen, whilst the members of the second, with two ethylene linkages, take up two molecules of the bromine, for example, bicyclic terpenes, such as pinene combine directly with bromine yielding a crystalline dibromide $C_{10}H_{16}Br_2$, which melts at 169°—170°, and when heated with aniline yields para cymene; on the other hand, a monocyclic terpene, such as limonene, absorbs bromine forming a tetrabromide melting at 104°—105°, and the other menthadienes also yield tetrabromides.

Another very important means available for the identification of the individual terpenes, is the study of the compounds which they form with the oxides of nitrogen and their derivatives. The first experiments made by Cahours, 1842, on the formation of the nitrites formerly called nitrosiles and also nitrosites, resulted in the production of phellandrene nitrite $C_{10}H_{16}N_2O_3$; of this there are alpha and beta modifications which also exist as cis and trans forms; from the alpha phellandrene nitrite, one melts at 112°-113°, and the other melts at 105°; whilst the β phellandrene nitrite also yields two modifications, one melting at 102° and the other at 98°. As an outline of the method used, the phellandrene, in ligroine solution, is treated with aqueous sodium nitrite and then dilute acetic acid added, whereupon the nitrite separates out as a crystalline substance.

In 1874, Tilden discovered that certain terpenes reacted with nitrosyl chloride NOCl. Originally the experiment was carried out in the following way: in the first place nitrosyl chloride was made—the nitrous fumes generated by the action of nitric acid upon arsenious oxide are passed into well-cooled strong sulphuric acid, when crystals of nitrosyl sulphate gradually separate out, these are mixed with dry sodium chloride and gently distilled, when nitrosyl chloride distils over and can be dissolved in petroleum spirit; the solution is then added to the terpene, for example, pinene gives at first a fine blue colouration, which persists for some time if the mixture is kept cool, but fades later on. This mixture, containing the nitroso chloride, is diluted with alcohol, which results in the formation of a white crystalline precipitate of pinene nitroso-chloride, having the formula—



Such nitroso-chlorides are decomposed by treatment with aniline or with dimethyl aniline, giving respectively a diazo com-

pound or a nitroso compound and the hydrocarbon is regenerated: this is very interesting, because it is the only case in which pinene can be recovered from a compound unchanged in constitution. Instead of using the specially prepared nitrosyl chloride, O. Wallach found that an alkyl nitrite, such as amyl or ethyl nitrite and hydrochloric acid, could be used when added to the terpene in glacial acetic acid solution :—

$$R{\cdot}ONO + HCl = R{\cdot}OH + NOCl$$

To illustrate the practical utility of this reaction one may take the examination of oil of orange peel for adulteration with turpentine. The essential oil is carefully distilled, and any portion coming over below 170°C should not yield pinene nitroso chloride and nitroso pinene (derived from added oil of turpentine). The test is conducted thus :—

Dissolve 5 c.c. of the fraction to be tested in one half its volume of glacial acetic acid, add 5 c.c. of amyl nitrite, cool thoroughly in a freezing mixture and add very gradually 5 c.c. of a mixture of equal volumes of hydrochloric acid and acetic acid. Collect any crystals which separate from the blue or greenish liquid by filtering them off at the pump and washing them with a few drops of alcohol; these will be the pinene nitroso-chloride. Transfer the crystals to a small flask, add 5 c.c of an alcoholic solution of caustic potash and heat the mixture on a water bath for 15 minutes, then pour the solution into ice cold water, filter off the crystals and wash them with water. Dry these crystals on a porous tile and re-crystallise them from alcohol and then determine their melting point. Pinene nitroso-chloride, as usually obtained, melts at 103°, but crystallisation from alcohol raises the melting point to 115°. When the nitroso-chloride is treated with the alcoholic potash, nitroso-pinene $C_{10}H_{14}:NOH$ is formed and this is derived from the pinene of the turpentine and melts at 131°-132°C., whereas nitroso-limonene or carvoxime from limonene, one of the normal constituents of oil of orange peel, melts at 72°.

The formation of nitrosates :—

If a terpene is treated with amyl nitrite in the presence of nitric acid, the oxide of nitrogen N_2O_4 or $NO{\cdot}ONO_2$ is first produced :—

$$R{\cdot}ONO + HNO_3 = R{\cdot}OH + NO{\cdot}ONO_2$$

and then reacts with the terpene to give a nitrosate :—

$$C_{10}H_{16}\langle\begin{matrix}NO\\ONO_2\end{matrix}$$

In general, the nitrosates are more soluble than the nitroso chlorides and often will not crystallise, but they have been found useful in the separation of definite compounds. For example, it has been found that the unsaturated salts of the terpenes with two ethylene linkages yield nitroso chlorides or especially nitrosates as readily as the corresponding hydrocarbons, so that the liquid limonene and dipentene hydrochlorides, can be readily precipitated by the addition of an alkyl nitrite and hydrochloric acid or nitric acid so as to form crystalline insoluble nitroso chlorides or nitrosates according as the formula is one of the following :-

$$C_{10}H_{16}\begin{matrix}Cl{\cdot}NO\\HCl\end{matrix} \quad \text{and} \quad C_{10}H_{16}\langle\begin{matrix}Cl.NO\\HONO_2\end{matrix}$$

These are called respectively hydro-chlor-nitroso-chlorides and hydro-chloro-nitrosates; these compounds are very interesting in that they crystallise with the greatest ease, but, unfortunately, are not stable and decompose on attempting to melt them.

Another reaction of the greatest importance in connection with the terpenes, is the formation of nitrolamines when nitroso chlorides, nitrosites, nitrosates, etc., enter into combination with certain organic amino compounds or bases :—

$$C_{10}H_{16}\langle\begin{matrix}NO\\Cl\end{matrix} + R{\cdot}NH_2 = C_{10}H_{16}\begin{matrix}NO\\R{\cdot}NH_2Cl\end{matrix}$$

Forming a nitrolamine hydrochloride. Nitrolamines may be prepared from such terpenes as pinene, limonene, sylvestrene and terpinene. They are characterised by the fact that they crystallise well, are stable, and possess definite melting points. Using pinene as an example, it can be shown that these nitrolamines may be very important factors in the identification of terpenes. The pinene nitrolamines are produced by the action of primary or secondary bases on pinene nitroso-chloride :—

$$C_{10}H_{16}NOCl + R_2:NH = C_{10}H_{16}NO{\cdot}NR_2HCl$$

and by using an excess of the base or some other simple means, the hydrochloric acid is removed, giving rise to the free nitrolamines; the chief bases used are benzylamine $C_6H_5{\cdot}CH_2{\cdot}NH_2$ and piperidine $C_5H_{10}{\cdot}NH$. The following table of the pinene nitrolamines will explain itself :—

Table of pinene nitrolamines and their melting points.

Pinene nitrol	ammonia ..	123°-125°C
,, ,,	piperidide ..	118°-119°C
,, ,,	propylamine	96°C
,, ,,	amylamine ..	105°-106°C
,, ,,	allylamine ..	94°C
,, ,,	benzylamine	122°-123°C

After this brief introduction to the terpenes, the individual members and their more important derivatives may be tabulated:—

Aliphatic terpenes.

Isoprene:— $\begin{matrix}CH_3\\CH_2\end{matrix}\!\!>\!C-CH=CH_2$

This hemiterpene is a liquid boiling at 33·5° and has a specific gravity of 0·699, and gives with hypochlorous acid a characteristic dichlorhydrin $C_5H_{10}O_2Cl_2$, melting at 80°-81° and a dibromhydrin melting at 86°. It does not form crystalline additive compounds.

Myrcene:—

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!C=CH\cdot CH_2\cdot CH=\overset{\displaystyle CH_3}{\overset{|}{C}}-CH=CH_2$$

This substance belongs to the open chain olefinic terpenes, and, like ocimene, is not a true terpene. Myrcene was isolated by Power and Kleber from oil of bay leaves and sassafras leaf oil; it is a liquid which boils under atmospheric pressure at about 167°, but at the same time polymerises; under 20 mm. pressure it boils at 67°-68°, the specific gravity is 0·802 and the refractive index is 1·4673; this is very low and indicates that it contains three double linkages. The hydrocarbon does not form crystalline addition compounds, but on oxidation is readily converted into succinic acid, melting at 184°-185°.

When myrcene is heated to 40°C with glacial acetic acid and dilute sulphuric acid there is produced an alcohol myrcenol $C_{10}H_{16}OH$, this is a liquid having an odour of lavender and yielding a crystalline phenyl urethane melting at 68°, and although myrcenol is isomeric with linalol, this urethane distinguishes between the two. It has already been stated that a β myrcene has been prepared synthetically by Ostromisslensky and Koschelev.

Ocimene:—

$$CH_2=\overset{\displaystyle CH_3}{\overset{|}{C}}-CH_2\cdot CH_2\cdot CH=\overset{\displaystyle CH_3}{\overset{|}{C}}-CH=CH_2$$

This substance was discovered by van Romburgh in 1901, in the leaves of ocimum basilicum. It is a liquid boiling at 172°, has a specific gravity of 0·801-0·803, and a refractive index of 1·4857. Enklaar discovered that when ocimene was heated it was converted into an isomer, allo-ocimene boiling at 188°. This allo-ocimene is considered to have the formula:—

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!C=CH\cdot CH_2\cdot CH=\overset{\displaystyle CH_3}{\overset{|}{C}}-CH=CH_2$$

Aliphatic terpene alcohols.

Geraniol:—

$$(CH_3)_2C=CH\cdot CH_2\cdot CH_2\cdot \overset{\displaystyle CH_3}{\overset{|}{C}}=CH\cdot CH_2OH$$

This alcohol is of the utmost importance and is isolated on a large scale from either palmarosa or citronella oils, it occurs very widely distributed in essential oils such as citronella, lemon grass and the principal geranium oils, which are derived from the fresh herbs of various species of pelargonium, such as the varieties cultivated in France, Spain, Algeria, and Corsica. It occurs, associated with citronellol, in the rose oils and in smaller amounts in the oils of ylang ylang, lavender, neroli, petitgrain, spike, sassafras and linaloe. In addition to occurring as the free alcohol, it is also found as the esters of acetic and tiglic acid; further the geranium oils contain considerable quantities of the free alcohol, together with geraniol acetate and small quantities of the esters of acetic, caproic, butyric, and valerianic acids.

In order to isolate geraniol from the oils which contain it in sufficient quantity, it is first necessary to boil the oil with alcoholic potash or the like to bring about the hydrolysis of the esters, after which the residual oil is carefully fractionated, *in vacuo*. In this way a fraction rich in geraniol is obtained and after drying is ground with anhydrous calcium chloride with which the geraniol forms a solid mass. The mass is well washed with petroleum ether or benzene and then rapidly filtered so as to avoid contact with air or moisture, and finally this calcium chloride compound of geraniol is decomposed into its constituents by mixing with water. The geraniol separates as an oil which is distilled and collected between 228°-230°. To obtain a pure geraniol of fine aroma is an exceedingly difficult operation, and much skill and knowledge is necessary in order to obtain a first-class product. Pure geraniol is a liquid having

a sweet rose-like odour; at 760 mm. the boiling point is 229°-230°, at 18 mm. it is 121° and at 10 mm. is 110°-111°; the specific gravity at 15° is 0·883 to 0·886, and the refractive index at 20° is 1·4766 to 1·4786.

Nerol is a stereo chemical isomeride of geraniol (*v.s.*)

This alcohol is an exceedingly difficult one to isolate, and it occurs chiefly in otto of rose and neroli oil. The oils which contain it also contain much geraniol and this is first removed with calcium chloride and from the residual oil the nerol can be isolated by preparing the phenyl urethane or the allophanate. Pure nerol has a boiling point of 115°-117° at 17 mm., the specific gravity is 0.881 at 15° and the refractive index is 1·47539 at 15°. This alcohol has a very sweet and penetrating odour and the commercial article boils at 226°-227° under 17 mm.

Linalol—

$$\begin{matrix}CH_3\\ CH_3\end{matrix}\!\!>C{=}CH{\cdot}CH_2{\cdot}CH_2{\cdot}\underset{OH}{\overset{CH_3}{C}}{-}CH{=}CH_2$$

This important alcohol is isomeric with geraniol, but is of quite different constitution. It is found very widely distributed in nature and is the principal constituent of linaloe oil in which it occurs in the free state, it is also found in considerable quantities as linalyl acetate in bergamot, and lavender oils and in various forms in the oils of petitgrain, neroli, ylang ylang, cananga, limes, sage, spike, thyme, lemon, origanum, sassafras leaf, Russian spearmint and basil. From oils rich in linalol and its esters, the linalol is separated by fractionation preceded by saponification, but it is rather doubtful whether pure linalol has ever been obtained. It is an optically active alcohol and whilst both varieties occur in essential oils the laevo variety is the more usual. In 1914, Paolini and Divizia, prepared a pure linalol by conversion into linalyl hydrogen phthalate and crystallisation of the strychnine salt, followed by treatment with alkali. Linalol is a rather unstable alcohol, having a boiling point 197°-199°; under 10 mm. it boils at 85° to 87°; the specific gravity varies from 0·870 to 0·875, the optical rotation is variable according to the source and purity of the alcohol, but the limits—20° 7′ to + 19° 18′ are representative, the refractive index varies from 1·4630-1·4690. This alcohol can be identified by means of its phenyl urethane melting point 65°-66° or the naphthyl urethane melting at 53°.

Citronellol—

$$CH_2{=}\overset{CH_3}{C}{-}CH_2{\cdot}CH_2{\cdot}CH_2{\cdot}\overset{CH_3}{C}H.CH_2{\cdot}CH_2OH$$

This alcohol is found in dextro and laevo rotatory forms in the rose geranium oils, whilst otto of rose itself contains the laevo form; it also occurs associated with the corresponding aldehyde in citronella oil. This alcohol very closely resembles rhodinol, indeed it is also known as rhodinol, reuniol, and roseol; actually, however, true rhodinol has the constitution

$$\begin{matrix}CH_3\\ CH_3\end{matrix}\!\!>CH{\cdot}CH_2{\cdot}CH_2{\cdot}\overset{CH_3}{C}H{\cdot}CH_2{\cdot}CH_2OH$$

and is a liquid with a pleasant rose-like odour, its acetate boils at 115° under 10 mm., the butyrate at 142°-143° under 13 mm., the isobutyrate at 135°-137° under 13 mm., and the benzoate at 194°-195° under 12 mm. Pure citronellol was obtained by Wallach from its admixture with geraniol, by heating the two alcohols with water under pressure at 250°, when the geraniol was changed into hydrocarbons. It can also be obtained by the help of phthalic anhydride, as the citronellol acid phthalic ester is an oil. Citronellol boils at 225°-226°, has a specific gravity of 0·860 to 0·862, its rotation varies from 4° 20′ to + 4°, and its refractive index is between 1·4586 and 1·4589. It can be identified by its silver phthalate which melts at 125°-126°.

Aliphatic terpenes aldehydes and ketones.

Citral or geranial—

$$\begin{matrix}CH_3\\ CH_3\end{matrix}\!\!>C{=}CH{\cdot}CH_2{\cdot}CH_2{\cdot}\overset{CH_3}{C}{=}CH{\cdot}CHO$$

This aldehyde is found in the oils of Backhousia citriodora, balm, bay, cedrat, lemon, lemongrass, limes, orange, pimento and verbena. It results when geraniol or linalol is oxidised with chromic acid, and it can be obtained in other ways. This substance exists in two isomeric forms corresponding to the alcohols nerol and geraniol. It can be isolated from essential oils by treating them with sodium bisulphite, with which it forms a soluble crystalline compound, which can be isolated and which

on treatment with sodium carbonate, liberates the free citral. Citral is a yellow oil having a boiling point of 228°-229° at 760, of 117°-119° at 20 mm., of 110°-112° at 12 mm., the specific gravity is 0·890-0·897, the refractive index is 1·4891-1·493. It can be identified by its semi-carbazone melting at 164° in the case of α citral or at 171° for the semicarbazone of β citral. Citral is very easily decomposed; for example, by the action of acids and caustic alkalies it becomes cymene whilst boiling with potassium carbonate decomposes into acetaldehyde and methyl heptanone, this latter also occurs in lemongrass oil. It is important to remember that citral also combines with a weak solution of sodium sulphite in the presence of sodium bicarbonate, whilst citronellal only combines with concentrated solutions and methyl heptanone does not combine at all in alkaline solutions, and these facts afford a method by which citral can be separated from citronellal and methyl heptanone. Neral, is considered to be β citral and is obtained by the oxidation of nerol, it has a specific gravity of 0·8888 and its refractive index is 1·49001. Citral is exceedingly important as the flavouring substance of the oil occurring in the rind of lemons and further as the raw material for the manufacture of ionone or artificial violet oil.

Citronellal—

$$CH_2{=}\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{C}}\!\!-\!CH_2{\cdot}CH_2{\cdot}\overset{\displaystyle CH_3}{CH}{\cdot}CH_2{\cdot}CHO$$

This substance is found to the extent of 95 per cent. in the oil of eucalyptus citriodora and also in the citronella oils, it is a liquid having a boiling point of 205°—208,° or at 25 mm. 103°—105°, the specific gravity is from 0·855—0·860 and the refractive index from 1·444-1·4481, its optical rotation is usually dextro from +8° to +12° and that derived from Java citronella oil is laevo rotatory. This aldehyde is extremely sensitive to acids and alkalies; with acids isopulegol is formed and finally cymene, whilst caustic soda converts it into a resin: it can be identified by means of its semicarbazone which melts at 84°.
Methyl heptenone

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>\!C{=}CH{-}CH_2{-}CH_2{\cdot}CO{-}CH_3$$

This occurs in the oils of lemon, lemongrass, citronella, linaloe and palmarosa. It is a liquid having an odour of amyl acetate, boils at 170°—174°, has a specific gravity of 0·850—0·855 and a refractive index of 1·438-1·440. It gives a semicarbazone melting at 136°—138°, but its oxime is a liquid boiling at 115° at 15 mm. and, though it forms a bisulphite compound, the original ketone cannot be regenerated from this.

Aliphatic sesquiterpene.

An olefinic sesquiterpene called sesquicitronellene $C_{15}H_{24}$, has been isolated from Java citronella oil; it boils at 270°—280°, has a specific gravity of 0·849, a refractive index of 1·5325, and is slightly dextro rotatory.

Aliphatic sesquiterpene alcohol.

Farnesol $C_{15}H_{25}{\cdot}OH$. This alcohol was discovered in 1904 in otto of rose, and also in acacia oils, musk seed oil and lime blossom oil. It is a liquid having an exceedingly pleasant odour, and boiling at 160° under 10 mm., whilst the specific gravity is 0·894, and the refractive index 1·488; solid derivatives of this alcohol have not been obtained.

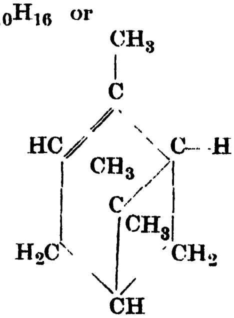
Aliphatic sesquiterpene ketone.

Doremone. $C_{15}H_{26}O$.

This was discovered in 1917, and isolated from oil of gum ammoniacum; it is a liquid boiling at 145°—155° under 12 mm., it has a specific gravity of 0·8765, and a refractive index of 1·4716; the rotation is +3°30′ and its oxime melts at 88°, whilst its semicarbazone melts at 124°.

The bicyclic terpenes.

Pinene. $C_{10}H_{16}$ or



This hydrocarbon occurs in both dextro and laevo rotatory forms, and is very widely distributed as a constituent of essential oils. It forms the chief constituent of the turpentine oils, and is found in such essential oils as pine, eucalyptus, camphor, coriander, fennel, juniper, rosemary, mace, lemon,

spike, thyme, etc. There are several isomeric forms, of which the α and β varieties, are well known; actually α pinene is the ordinary variety; a chemically pure pinene can be obtained from pinene nitrosochloride. This boils at 155°—156°, has a specific gravity of 0·858 at 20°, and a refractive index of 1·4655; this is considered to be the α variety. The dextro pinene has been isolated from Grecian turpentine and has an optical rotation of +48°.

β pinene, also known as nopinene, occurs in the oils of hyssop, and pinus sibirica.

Firpene $C_{10}H_{16}$ isolated from the turpentine of the Western fir, closely resembles pinene. It boils at 152°—153°, has a specific gravity of 0·8598, and a rotation of —47°, whilst its refractive index is 1·47299.

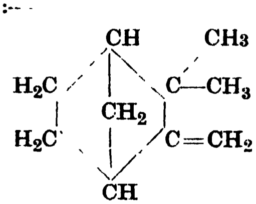
TABLE OF THE PINENE GROUP.

	B.P.	Sp. Gr.	n.
α pinene ..	155°—156°	0·858	1·4655
β pinene ..	162°—163°	0·866	1·7224
Firpene ..	153°—154°	0·860	1·4730

Derivatives of pinene, etc.:

A crystalline dibromide melts at 169°—170°, a mono-hydrochloride melts at 125° and boils at 207°—208°. The nitroso chloride melts usually at 103°, but this can be raised to 115°, and nitrosopinene melts at 130°—131°. The foregoing are from α pinene.

Camphene:—

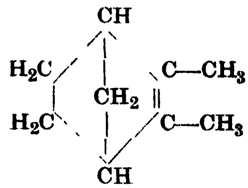


This is a solid terpene, and there are apparently a number of very closely related varieties. The dextre variety occurs in camphor, ginger and spike oils, the laevo variety is found in citronella, valerian and certain pine oils, the so called natural camphene is found in Siberian pine needle oil, and citronella oil. It is a crystalline solid, having as a usual melting point 49°—50°, though it can be raised to 54°. It boils at 160°—161°, and has a specific gravity of 0·850 at 48°. Of its derivatives, the dibromide melts at 90°, the hydrochloride melts at 150°—152°, and it does not give a nitrosochloride.

Fenchene. $C_{10}H_{16}$.

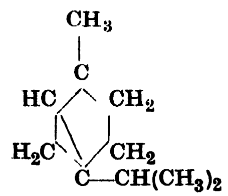
This hydrocarbon does not occur in essential oils, and will, therefore, not be described.

Santene.



This terpene has been found in sandalwood oil, and in Siberian turpentine oil. It is sometimes called norcamphene, and is a liquid boiling at 140°; the specific gravity is 0·863—0·870, and the refractive index 1·466—1·470.

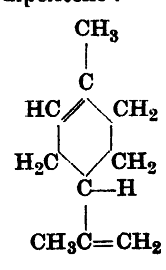
Sabinene.



This was originally isolated from savin oil, and has also been found in cardamom oil and marjoram oil. It is a liquid boiling at 162°—170°, with a specific gravity of 0·840, the refractive index is 1·466 and the substance is optically active.

Monocyclic terpenes or menthadienes.

Limonene and dipentene:—

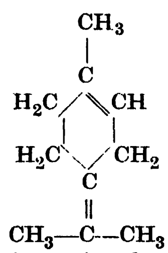


It appears probable that dipentene is the racemic form of limonene, though more proof of this statement is still required. Limonene is found in large quantities in the oils of lemon, orange, dill, caraway and bergamot as the dextro variety, whilst Russian peppermint, American spearmint and the pine oil from Abies alba contain the laevo variety. Limonene boils at 175°-176° and has a specific gravity of 0·846-850 and a refractive index 1·474-1·475, whilst the rotatory power is —105° to +106°. Limonene contains two ethylene linkages and forms a

tetra bromide melting at 104°-105°. The nitroso chloride occurs in four different forms, two, the alpha and beta, from dextro limonene and two from laevo limonene. Dipentene is found in Swedish and Russian turpentines and also in the oils of bergamot, camphor, cubebs, fennel, thyme and nutmeg, it is also a product of the destructive distillation of various resins, it boils at 178°, has a specific gravity of 0·845 and a refractive index of 1·4720-1·4730. Its chemistry has been fully elucidated by W. H. Perkin, who succeeded in making it synthetically and at the same time accomplished the synthesis of terpineol. The dipentene tetra-bromide is less soluble in ether than is limonene tetra-bromide and it melts at 126°, whilst the nitrosochloride occurs in two forms.

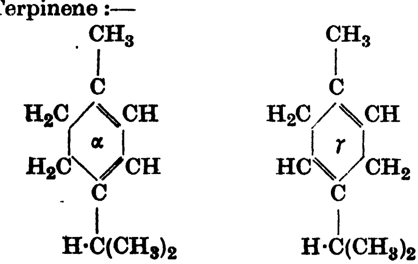
Terpinolene :—

$C_{10}H_{16}$ or



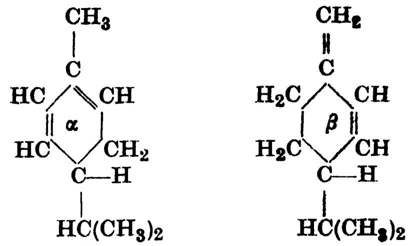
Results from the isomeric changes of other terpenes under the influence of sulphuric acid and also occurs naturally in oils of elemi and coriander. It is a liquid boiling at 185°-190°.

Terpinene :—



This terpene was discovered in oil of cardamoms and three isomeric forms are known. The α terpinene is a constituent of the oils of cardamoms, coriander and elemi. The β variety has not been found in essential oils, whilst the γ form is contained in the oils of ajowan, coriander, lemon and yellow pine. When certain terpenes undergo isomeric change they yield terpinene, which is a mixture of the α and γ varieties, and is optically inactive, boils at 180°, has a gravity of 0·842 and forms a nitrosite melting at 155°.

Phellandrene :—

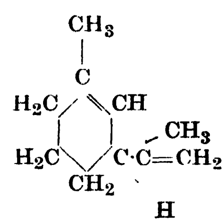


The dextro form of this is found in the oils of elemi, bitter-fennel, and water-fennel whilst the laevo form is in certain eucalyptus and pine needle oils. In 1886, Pesci discovered a variety of phellandrene in water fennel oil which has been called the β form. α phellandrene is a liquid boiling and an optical rotation of +40° to—84°, at 173°-175° has a specific gravity of 0·848 this α variety gives two nitrites, which are probably cis and trans configurations, one melts at 113° and the other at 105°.

The β phellandrene has a specific gravity of 0·850 to 0·854 and a rotation +14°, it also yields two nitrites, one melting at 102° and the other at 98°.

Terpenes of the meta series :—

Sylvestrene.



This is a dextro rotatory terpene found in Swedish pine oil, Russian turpentine and in certain pine needle oils. The liquid boils at 176°-177° and has a specific gravity of 0·850 and a rotation of +66°. It gives an interesting reaction when a drop of strong sulphuric acid is added to a solution of the sylvestrene in acetic anhydride, the result being a deep blue colouration. The same reaction is given by carvestrene, and both of these terpenes are derivatives of metacymene and have been prepared synthetically by W. H. Perkin, carvestrene in 1907 and sylvestrene in 1910.

Terpene alcohols and ethers.

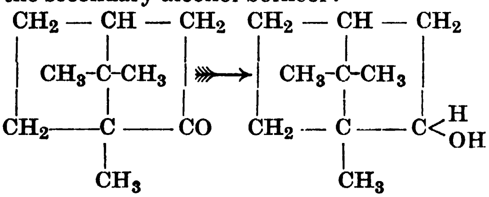
Terpineol :—$C_{10}H_{17}·OH$

This alcohol occurs in several isomeric forms, d-terpineol has been found in the oils of cardamoms, lavender, marjoram

spike, etc., whilst an inactive form is known to occur in cajuput oil. The chemical constitution of terpineol admits of there being four isomeric forms, and three of these are well known. The liquid terpineol of commerce obtained from terpin hydrate by the action of dilute sulphuric acid, is a fairly thick liquid, having a lilac odour, its specific gravity is from 0·935 to 0·945, and the boiling point varies from 210° to 220°. The pure α terpineol is optically inactive, melts at 35° and boils at 217°, the β terpineol melts at 32°, whilst the γ melts at 69°-70°. Much care is required in the manufacture of the liquid terpineol of commerce to insure its freedom from terpenes, which considerably modify its odour and affect its solubility.

Borneol :—

When camphor is reduced there is formed the secondary alcohol borneol :—



The dextro form is found as Borneo camphor in Dryobalanops camphora, whilst the laevo form is the camphor from Blumea balsamifera. The dextro form of borneol is also found in the oils of rosemary and spike lavender, whilst the laevo form is found in the oils of citronella, feverfew and valerian, There is also an isoboneol obtained by treating camphene with a mixture of sulphuric and acetic acids followed by saponification, it is a crystalline substance melting at 212°. Borneol melts at 203°-204°, and its specific rotation varies from —37°+37°. It will be convenient to deal with the medicinal value of borneol compounds at this point.

Of the borneol containing oils, some of the most interesting are the pine oils, many species of which are characterised by containing varying quantities of bornyl esters, usually in the form of bornyl acetate. This acetate, found in various pine oils, occurs to the extent of 30 or 40 per cent. in oil of pinus sibirica, it has a most refreshing and fragrant odour, being an absolute necessity for the reproduction of pine odours. It is prepared artificially by the action of acetic anhydride on borneol, or by the treatment of borneol with glacial acetic acid in the presence of a small quantity of a mineral acid; when quite pure and crystallised from petroleum ether, it forms rhombic hemihedric crystals melting at 29°, and is either dextro or laevo 40° according to the alcohol from which has been prepared. It has a specific gravity of 0·991, a refractive index of 1·465 to 1·4665, and boils at 98° under 10 mm. pressure, and is soluble in three volumes of 70 per cent. alcohol. The commercial article is usually a mixture of dextro and laevo varieties, and is frequently liquid, and it remains in a state of superfusion when it has once been melted; it should contain at least 98 per cent. of the ester and the gravity should be between 0·988 and 0·992.

It is well known that the oil of pinus sylvestris was official in the Pharmacopœia of 1885, but in 1895, Umney showed that such oils as were in commerce under that name were. actually from other species, more especially from Abies excelsa. In 1898, the oil of Pinus pumilio took its place in the B.P. This is an oil with an extremely pleasant odour, and containing varying proportions of bornyl acetate, usually about 4 per cent. It was suggested that this again should be replaced by the most fragrant of the pine series, such as pinus sibirica. At one time this oil was distilled in very large quantities in northern Russia and on the slopes of the Ural mountains.

In the class of oils containing borneol and its esters, the most important member is rosemary oil, though but little of this oil is now produced in England. The principal countries producing rosemary oils are France, Spain and North America, and at one time Dalmatia, though this almost ceased to appear on the market before the war. The English oil is characterised by a fineness of bouquet which is certainly not equalled by any of the others. These oils may be dextro or laevo rotatory, and the proportion of borneol or of alcohols calculated as borneol in rosemary oils, varies very considerably, some of the finest containing as low as 8 per cent. of borneol, whilst in others there is as much as 22 per cent., and the bornyl acetate is between 4 and 6 per cent.

Much attention has been given to the use of the esters of borneol and menthol for medicinal purposes, and the medical profession has for many years appreciated

the value of valerian for the treatment of nervous ailments, but it is only in recent years that it has been recognised that the root owes its chief physiological activity to the essential oil contained in it, and that its therapeutic value is due to bornyl-iso-valerianate,

$$C_{10}H_{17}OOC \cdot CH_2 \cdot CH(CH_3)_2$$

Under the name of "Bornyval" this substance was introduced into medicine, and its value is very considerable as an anti-spasmodic and sedative and as a general tonic for the nervous system. This substance may be regarded as the natural active constituent of valerian root; it is prepared artificially by the action of iso-valeric acid on borneol. It is a limpid liquid of a rather pleasant aromatic odour, slightly reminiscent of valerian; it boils at 255°—260°, and has a specific gravity at 20°C. of 0·0951—956. This ester is like terpineol acetate rather resistant to saponification and requires an excess of alkali and at least two hours boiling to complete the reaction. Average good qualities correspond to the following characters:—specific gravity, 0·953—0·956; optical rotation about −35°, refractive index, 1·4620—1·4635, and the boiling point is 128°—130° at 10 mm.

Gynoval, valisan and such like bodies have been used in medicine; gynoval is the iso-valerianic ester of iso-borneol,

$$(CH_3)_2 : CH \cdot CH_2COOC_{10}H_{17}$$

It is a colourless neutral liquid with a peculiar aromatic odour and a slightly oily taste. It boils at 132°—137° under 12 mm. and has a specific gravity of 0·952—0·957. The preparation is very sparingly soluble in water, but it dissolves readily in alcohol or ether. The pharmacological investigation of this substance shows it to possess the typical action of valerian, whilst its toxicity is but slight.

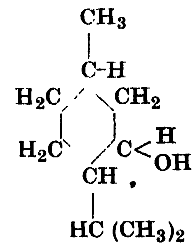
The bromo-iso-valerianic ester of borneol was introduced under the name of "Valisan,"

$$(CH_3)_2\ CH \cdot CH\ Br \cdot COOC_{10}H_{17}$$

It is a liquid having a slight odour and a mild taste, and is insoluble in water, but dissolves easily in organic solvent; at one time it was called "Eubornyl," and is stated to be a useful sedative for the treatment of headache and insomnia.

These substances were nearly all of foreign origin, and have been introduced to show the utility of some of the constituents of essential oils, and several other esters of borneol, such as the formate, occur in essential oils, whilst bornyl butyrate, a liquid boiling at 120°—121° under 10 mm., and having a specific gravity of 0·966 and a refractive index of 1·4638 and a rotation of +22, together with the propionate, a liquid having a boiling point of 109° to 110° and a specific gravity of 0·979, and a rotation about +25° with a refractive index, are in commerce.

Menthol:—



This is a crystalline alcohol which separates on cooling oil of peppermint. When pure, it melts at 44°, but usually the commercial melts slightly lower, between 43° and 43·5°, and certainly not below 42·5°. The boiling point is 217°, if care be taken to have the stem of the thermometer entirely immersed in the vapour, otherwise it will record about 212°. Its specific rotation is about —50° in alcoholic solution, and only the laevo variety is found in nature.

The esters of menthol have also had wide application and menthyl acetate and valerianate occur in peppermint oil. The menthyl acetate is easily obtained by the acetylation of menthol and is a liquid boiling at 228°, the specific gravity is 0·925 to 0·930. the specific rotation is —72° to +79°, and the refractive index is 1·446-1·447. Menthol valerianate found in American peppermint oil has a refreshing odour, which is not distinctive either of menthol or of valerianic acid. At one time a mixture of menthol valerianate and free menthol was in commerce under the name of "Validol," this was a colourless viscous liquid with a pleasant odour and often contained up to 30 per cent. of free menthol, and was recommended to be taken on sugar as a preventive of sea sickness. There was also a liquid camphorated validol containing 10 per cent. of camphor and 90 per cent. of the validol, this was offered as a local anæsthetic for toothache. Another ester was the menthol ethyl glycollate:—

$$C_{10}H_{17}{\cdot}O{\cdot}CO{\cdot}CH_2{\cdot}O{\cdot}C_2H_5$$

introduced under the name "Coryfin," it was a colourless liquid with a barely

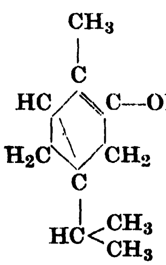
perceptible odour of menthol, and was intended to be used as a cure for nasal catarrh of the nose and throat and to be rubbed on the forehead to produce a refreshing cooling feeling, which would persist a long time and alleviate nervous headache. Another substance, menthol borate :—

$$BO_3\ (C_{10}H_{19})_3$$

was introduced under the name of "Estoral." It was obtained by the action of boron trichloride on menthol and was a white crystalline powder intended to be made into a snuff for catarrh of the nose. It was a fairly stable substance, insoluble in water and alcohol, but in contact with moisture and mucous membranes it broke up fairly rapidly into its components boric acid and menthol. The salicylic ester of menthol has been made and forms a colourless liquid insoluble in water and boiling at 189° under 11 mm.

Sabinol :—

$C_{10}H_{16}O$ or



This alcohol was discovered by Fromm (1898) in savin oil, in which it occurs as an acetate and as the free alcohol, it is a slightly odorous liquid boiling at 210° to 213°, and has a specific gravity of 0·943-0·950 and a refractive index of 1·488. There is also known a pure dextro sabinol boiling at 208° and having a specific gravity of 0·9518 and a refractive index of 1·4895, whilst the rotation is +76°.

Fenchyl alcohol :—$C_{10}H_{17}OH$

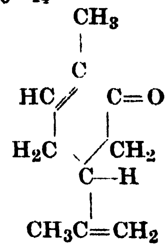
It is obtained from the yellow pine oil which resulted from the steam distillation of old stumps of Pinus palustris, it is crystalline, melts at 45° and boils at 202°-203°.

Thujyl alcohol :—$C_{10}H_{17}OH$.

Is isolated from oil of wormwood and can also be produced by the reduction of thujone, it is a liquid boiling at 210°-212°, with a specific gravity of 0·927.

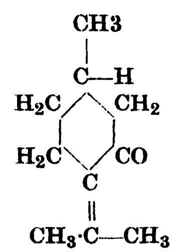
Monocyclic terpene ketones.

Carvone :—$C_{10}H_{14}O$ or



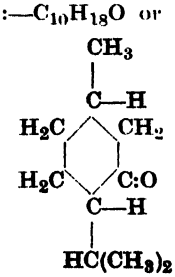
The dextro variety occurs in caraway and dill oils, whilst the laevo form is found in the oils of kuromoji and spearmint. It is a ketone with two double bonds and is a derivative of di-hydro cymene. Its oximes are identical with the nitroso limonenes. Pure carvone boils at 230°-231° and has a specific gravity of 0·963 to 0·966 and a rotation of −59°, whilst the refractive index is 1·497-1·500. Carvone forms an additive compound with sulphuretted hydrogen, which crystallises well and from this compound it can be regenerated and this forms a means of preparing pure carvone.

Pulegone :—$C_{10}H_{16}O$ or



This is the chief constituent of the oils of pulegium (European pennyroyal) and hedeoma (American pennyroyal), it is a liquid boiling at 223°—224°, has a specific gravity of 0·929-0·936, a rotation of +20° to 25°, and a refractive index of 1·470. It forms the usual compounds that distinguish ketones, whilst the iso-pulegone differs in physical properties and does not combine with sodium bisulphite.

Menthone :—$C_{10}H_{18}O$ or

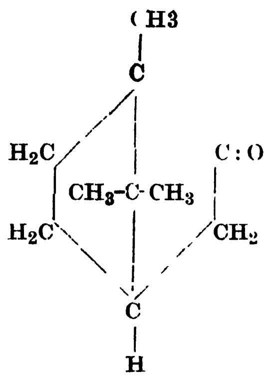


This substance is a saturated ketone found, together with menthol, in peppermint and hedeoma oils.

It is a liquid easily made by the oxidation of menthol, it boils at 207°, has a specific gravity of 0·896, a specific rotation of —29° and a refractive index of 1·449. Although this ketone yields the usual derivatives, it does not combine with sodium bisulphite.

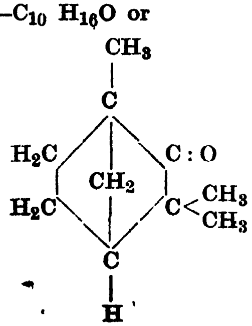
Bicyclic terpene ketones.

Camphor :—$C_{10}H_{16}O$ or



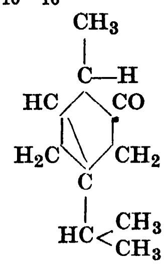
This substance occurs in the camphor tree, as a dextro rotatory form and other essential oils contain traces of it, the laevo variety has been found in the oil of Matricaria parthenium. It is a colourless, crystalline substance, melting at 175° and boiling at 204°. It has been made artificially on a commercial scale, starting with the raw material, turpentine; the synthetic product is optically inactive and is stated to be deficient in physiological properties. Camphor is not of great importance as a perfume substance, but enormous quantities are used in the manufacture of celluloid. There is a homologue of camphor called "Matico camphor," which is isolated from the oil of Matico leaves; it is crystalline and melts at 94°.

Fenchone :—C_{10} $H_{16}O$ or



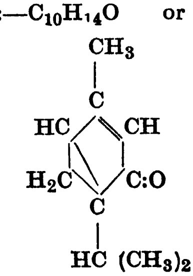
This substance was discovered in 1890, the dextro form occurs in oil of fennel and the laevo in thuja oil, it is an oil having a camphor-like odour and boils at 193°, when cooled it solidifies and then melts at about 5° C., the liquid product has a specific gravity of 0·946-0·948 and the rotation is —72°. It appears not to re-act either with sodium bisulphite or phenylhydrazine, though it does yield an oxime and a semicarbazone. Fenchone distilled with phosphorus pentoxide yields metacymene.

Thujone :—$C_{10}H_{16}O$ or



This is also known as tanacetone and salvone, and occurs in two modifications. The α form is the laevo variety, and is obtained from thuja oils, and boils at 170°. β thujone is the dextro variety and occurs as a constituent of the oils of sage, tansy and wormwood. Actually, both forms can be isolated from the oils of wormwood and sage. This ketone is a colourless liquid boiling at 201°, has a specific gravity of 0·912—0·917 and a refractive index of 1·450—1·451.

Umbellulone :—$C_{10}H_{14}O$ or



Power and Lees discovered this bicyclic ketone in Californian laurel oil; it is a liquid boiling at about 98°C. under 10 mm., and has a specific gravity of 0·958 and a refractive index of 1·4895, and is laevo rotatory.

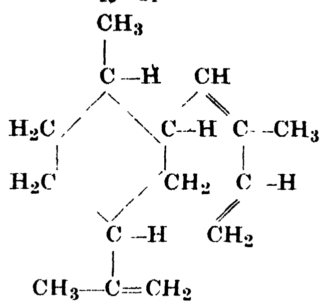
Monocyclic sesquiterpenes.

Limene :—$C_{15}H_{24}$.

This substance was discovered by Burgess and Page in the oils of lime and of lemon, and is the same substance isolated from

oil of bisabol myrrh formerly called "bisabolene." It is a liquid boiling at 262°, and resinfies very easily.

Zingiberene :—$C_{15}H_{24}$ or



It is isolated from oil of ginger, boils about 270° and is optically active. Much work has been done recently on this terpene. The alcohol zingiberol is also in ginger oil together with zingerone.

Bicyclic sesquiterpenes

Cadinene : —$C_{15}H_{24}$.

This occurs as a constituent of the oils of cade, cubebs, camphor, cedar wood, galbanum, juniper, patchouli and savin. It is a liquid boiling at 272°—274°, has a specific gravity of 0·921 and a refractive index of 1·5064, and is laevo rotatory. It easily oxidises, and resinfies on exposure to the air. Oil, in which these changes have commenced, gives a remarkable reaction; when dissolved in glacial acetic acid or chloroform and shaken with a few drops of strong sulphuric acid, a green colour developes gradually changing to blue, and with a slight warming the mixture becomes red.

Caryophyllene :—$C_{15}H_{24}$.

Is contained in oils of clove and copaiba. It is a liquid boiling at 258°—260°, and has a specific gravity of 0·908 and a refractive index of 1·5009. When boiled with glacial acetic acid and sulphuric acid caryophyllene yields an alcohol which melts at 96° and boils at about 288°, and from this, by the elimination of a molecule of water, there results the isomeric sesquiterpene "Clovene," which boils at 262° and has a gravity of 0·930, but this cannot be converted into a crystalline alcohol.

Humulene :—$C_{15}H_{24}$.

Is found in oil of hops and is not yet fully investigated, but appears to be a mixture of caryophyllenes.

Santalene :—$C_{15}H_{24}$.

Occurs in two forms in sandalwood oil; the alpha variety boils at 252°—253°, and the beta variety at 261°—262°.

Selinene :—$C_{15}H_{24}$.

Is found in oil of celery, is dextro rotatory +35°, and boils about 270°, at 120° under 16 mm., the specific gravity is 0·9197 and the refractive index 1·4986.

Aromadendrene : —$C_{15}H_{24}$.

Appears to occur mainly in the eucalyptus oils, and in a liquid boiling about 263°.

Tricyclic sesquiterpene :—

Cedrene : —$C_{15}H_{24}$.

This is found in oil of cedar wood and is a liquid boiling at 262°—263°, and has a specific gravity of 0·936, and is laevo rotatory.

Bicyclic sesquiterpene alcohols.

Santalol : —$C_{15}H_{24}O$.

There are two forms of this alcohol, and they form together about 90 per cent. of sandalwood oil. The alpha compound is a liquid boiling at 300°—301°, the specific gravity is 0·985, and the rotation slightly dextro. The beta variety is stated to boil at 309°—310°, has a specific gravity of 0·986, and is laevo rotatory. In former days a salicylic acid ester of sandalwood oil called "Santyl," was in commerce as a colourless liquid offered for treatment of venereal disease, and a so-called methyl ester of santalol under the name of "Thyresol," in the form of a colourless liquid, boiling at 149°—156° under 16 mm, and having a gravity of 0·930, was introduced. There was also a neutral camphoric acid ester of santalol under the name of "Camphosal," C_8H_{14} $(COOC_{15}H_{23})_2$; it was a yellow oil having a bitter taste, and a feeble aromatic smell, and a specific gravity of 0·987.

Eudesmol : —

This is a solid alcohol found in eucalyptus oil, and melts at about 79°.

Tricyclic sesquiterpene alcohols.

Cedrol or cedar camphor :—$C_{15}H_{26}O$.

Is found in cedar wood and cypress oils as a crystalline compound melting at 87°, and boiling at about 293°.

Cubeb camphor :—$C_{15}H_{26}O$.

Can be obtained from oil of cubebs and melts at 70°C, and boils at 248°. Patchouli oil deposits a crystalline alcohol $C_{15}H_{26}O$ called a "camphor," which melts at 56°.

OBITUARY.

Sir William Stevenson Meyer, G.C.I.E., K.C.S.I., B.A. — Sir William Meyer, High Commissioner for India, and formerly Indian Finance Minister, died suddenly in London on October 19th. Son of the late Rev. Theodore J. Meyer, he was born on February 13th, 1860, and, at the age of nineteen, on completing his education at University College, London, gained entrance by competition to the Indian Covenanted Civil Service, in which he had a very distinguished career of nearly forty years' duration. After filling, with credit, numerous responsible posts in the Southern Presidency, he was called in 1898 to the seat of the Supreme Government to be Deputy Secretary in the Finance Department. Three years later he reverted to duty in Madras, and subsequently for about eighteen months was Editor of the monumental *Imperial Gazetteer of India*. Recalled to imperial headquarters, he was Financial Secretary to the Government of India from 1905 to 1909, when he was appointed Chief Secretary to the Government of Madras. He was a member of the Decentralisation Committee (1907-9), a delegate to the International Opium Commission at the Hague (1911-12), and a member of Lord Nicholson's Committee on Indian army administration (1912-13). He became Financial Member of Lord Hardinge's Council in June, 1913, as successor to Sir Guy Fleetwood Wilson. Sir William Meyer's term of office as Finance Minister was marked by unparalleled difficulties and he was subjected to some criticism, particularly in connexion with what the public commission presided over by Lord George Hamilton called the "lack of provision made for the wants of the Mesopotamia Expedition during the first sixteen months of its operations." Sir W. Meyer, however, claimed, as the then Secretary of State for India, Mr. Austen Chamberlain was authorised to tell the House of Commons, that nothing put forward as a military necessity had been refused. Moreover, the Commission recognised that no evidence had been produced to show that any urgent demand made by the military authorities was definitely rejected by the Finance Department.

Sir W. Meyer retired in 1918, and after his return to England took an active part in the organisation of Earl Haig's splendid movement on behalf of ex-officers and soldiers. In 1920 he was selected to be the first High Commissioner for India, and as doubtless such a strenuous worker would have desired, has died in harness.

He joined the Royal Society of Arts in 1901 and was a valuable member of the Indian Section Committee. The able paper he contributed to the Society in 1920 on "The Indian Currency System and its Developments" was described by one of the experts who spoke on the occasion as a classic on the subject and likely to be of great historical importance. More recently Sir William occupied the chair when Mr. Alexander Howard's paper on "The Timbers of India and Burma" was read.

He translated into English M. Chailley's "L' Inde Britannique," also revising the French text.

GENERAL NOTES.

Victoria and Albert Museum.—A number of interesting pieces of English furniture recently presented by Mr. Douglas Eyre have been placed on exhibition in Room 56 of the Woodwork Galleries of the Museum. These pieces of furniture date from the latter part of the 17th century to the middle of the 18th century; they have been handed down in the donor's family and thus have an important documentary interest. They include a winged armchair of about the year 1700 embroidered in coloured wools with David playing the harp before Saul, and other Biblical and mythological subjects; and a large double-back settee with three chairs and a stool of the time of James II. Among examples of the 18th century, the most valuable is a set of mahogany chairs, richly carved with ornament of the middle of the century and the crest of the Eyre family. This gift is of great importance in strengthening the English furniture in the Museum at a time when high prices and lack of money make it difficult for a Government institution to compete with wealthy collectors.

Artificial Silk in Italy.—The Italian artificial silk industry, says an American Consular report, has attained a considerable development both as regards capital invested, labour employed, raw material and actual production. The industry is a comparatively new one, being known in the world's markets for only 30 years and in Italy for about 15. It produces by means of four diverse systems a fibre from wood pulp, having a certain external likeness to natural silk and considerable affinity to mercerised cotton. The present amount of capital involved is about 420,000,000 lire, and by the end of 1923 it is estimated that the amount will be fully double the above figure. Twelve thousand workmen are now employed and by the close of 1923 it is estimated that the number will be about 20,000. Some of the raw materials used, *i.e.*, soda, carbon bisulphide, sulphuric acid are produced by native industries, and it is hoped that after a time the wood pulp may be also, though at present it is imported principally from Scandinavia. Considerable quantities of cloth, hosiery and knitted goods are being manufactured from the fibre.

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FRIDAY, NOVEMBER 3, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

NOTICE.

OPENING OF THE 169th SESSION.

The opening meeting of the 169th Session will be held on Wednesday, November 8th, when an address will be delivered by LORD ASKWITH, K.C.B., D.C.L., Chairman of the Council, on "The Value of Strikes and Lock-outs." The Chair will be taken at 8 p.m.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE CONSTITUENTS OF ESSENTIAL OILS.

By LIONEL GUY RADCLIFFE, M.Sc.Tech., F.I.C.

LECTURE III.—*Delivered April 3rd,* 1922.

The constituents of essential oils other than those derived from the various classes of terpenes are exceedingly numerous and varied in chemical constitution: it is, therefore, impossible to review the whole of them in this one lecture, and, indeed, those that can be dealt with, will have to be summarised very briefly. The hydrocarbons of the fatty series have already been mentioned, and as these are limited in interest they will not be dealt with further.

Aliphatic Alcohols.

Methyl alcohol :—CH_3OH.

This alcohol frequently occurs in essential oils in the free state associated with diacetyl and furfurol and the myristic methyl ester is found in oil of orris, the benzoic methyl ester in oil of ylang ylang, the salicylic ester in the oils of wintergreen and sweet birch and in small quantities in the oil of rue, cassie, cananga, and tuberose, whilst as the methyl ester of anthranilic acid, it is a most important constituent of the oils of neroli and jasmin.

Ethyl alcohol :—C_2H_5OH.

This has been found in the aqueous distillates from a few essential oils, especially if the vegetable material has begun to ferment. Its esters occur in many essential oils, *e.g.*, the butyric ester in oil of heracleum, the cinnamic ester in oils of styrax and kaempferia and the caproic ester in oil of cognac.

Normal butyl alcohol :—

$$CH_3(CH_2)_2{\cdot}CH_2OH$$

Has been found in an ester in chamomile oil, whilst isobutyl alcohol has been isolated from the aqueous distillation of eucalyptus amygdalina.

Iso-amyl alcohol :—

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CH{\cdot}CH_2CH_2{\cdot}OH$$

This occurs in the oils of eucalyptus globulus, and Bourbon geranium, and as esters in chamomile and cognac oils; in the eucalyptus oil mentioned above it occurs as an ester of eudesmic acid.

Normal hexyl alcohol :—

$$CH_3{\cdot}(CH_2)_4{\cdot}CH_2OH$$

Has been found in the oil of male fern and as a butyric ester in the oils of the heracleum species, whilst active hexyl alcohol occurs as an angelic acid ester in chamomile oil. It is a liquid boiling at 157°.

Heptyl alcohol : Oenanthyl alcohol :—

$$\begin{matrix}CH_3\text{———}\\CH_3(CH_2)_3\,CH_2\end{matrix}\!\!>CHOH$$

This has been found in oil of cloves, it is a liquid with a very powerful odour, boils at 157° and has a specific gravity of 0·8344, it is manufactured artificially by the reduction of heptyl aldehyde, *i.e.*, oenanthol. The calculated quantity of sodium is melted by heating in dry toluene, the mixture being then vigorously stirred to obtain the sodium in a fine state of division, after which the mixture is cooled in ice with continual stirring, then there is added very slowly a solution of oenanthol in glacial acetic acid and toluene. When reduction is complete water is added to dissolve the sodium acetate, the toluene layer is separated, dried and distilled, giving a 50 per cent. yield of heptyl alcohol.

Octyl alcohol :—$CH_3 \cdot (CH_2)_6 \cdot CH_2OH$

This has been found in the oil of heracleum as the acetic ester and in oil of pastinac as a propionate, whilst oil of male fern contains it as the isovalerianate. It is a liquid with a pleasant odour and boils at 196° and has a specific gravity of 0·8278.

Ethyl normal amyl carbinol : —

$$\begin{matrix} C_2H_5 \\ C_5H_{11} \end{matrix} > CHOH$$

This has been found in Japanese peppermint oil, and when pure boils at 179°, and has a specific gravity of 0·8276 and a refractive index of 1·42755 and is dextro rotatory. It does not form a phenyl urethane with phenyl isocyanate, but with alpha naphthyl isocyanate an alpha naphthyl urethane is obtained crystallising from methyl alcohol, with a melting point of 82°.

Nonyl alcohol : —$CH_3(CH_2)_7 \cdot CH_2OH$

This is found in sweet orange oil as the caprylic ester, it is extracted from this oil by saponifying the high boiling constituents and extracting the alcohol, which is then purified by converting it into its phthalic acid ester. The alcohol is a liquid with a roselike odour, slightly reminiscent of orange, it boils at 213° under normal pressure and has a specific gravity of 0·840. The isomeric methyl heptyl carbinol has been found in Algerian oil of rue and in clove oil, it is a liquid boiling at 195°-196° under 760 mm., and has a specific gravity of 0·8273.

Methyl normal nonyl carbinol : —

$$\begin{matrix} CH_3\text{———} \\ CH_3(CH_2)_8 \end{matrix} > CHOH$$

This secondary undecylic alcohol has been found in the oils of rue and trawas, which latter is a bright yellow oil of unpleasant odour obtained by distilling the leaves of Litsea odorifera, a tree found in Java; the alcohol boils at 232°.

Undecylenic alcohol : —

$$CH_2 : CH(CH_2)_8 \cdot CH_2OH$$

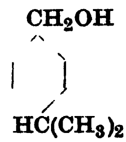
This liquid has been found in oil of trawas leaves, it crystallises on cooling and melts at—12° and boils at 128° under 13 mm.

The aromatic alcohols are of great importance, though comparatively few in number, and of these the following are the best known :—

Benzyl alcohol :—$C_6H_5 \cdot CH_2OH$.

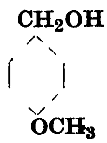
This occurs naturally both in the free state and in the form of esters in many essential oils, *e.g.*, cassie, gardenia, hyacinth, jasmin, narcissus, tuberose, wallflower and ylang ylang, it is found as the esters benzyl benzoate and benzyl cinnamate in storax and balsams of Peru and Tolu. It is an oily liquid with a very slight odour, boils at 205° under 760 mm., the specific gravity is 1·050 and the refractive index 1·53804.

Cumic alcohol :—



Has been found together with the corresponding aldehyde in oil of cumin. It is a pleasant smelling liquid, boiling at 246°.

Anisyl alcohol :—



This alcohol has been isolated from Tahiti vanilla, when pure it forms crystals melting at 25° and boils without decomposition at 259°.

Phenyl ethyl alcohol :—$C_6H_5 \cdot CH_2 \cdot CH_2OH$.

This alcohol is a natural constituent of neroli and rose oils, and is present in greater proportion in French rose oils than in the Bulgarian ottos; the French ottos, especially the extracted rose products, owe their perfume to this alcohol because, owing to the solubility of phenyl ethyl alcohol in water, the steam distilled rose oils are almost entirely without it, and this much affects their odour as compared with extracted rose concretes. The alcohol is largely manufactured and such products vary very much in odour and keeping properties. The pure alcohol has a fresh rose-like odour, boils at 220°—222° under 740 mm., the specific gravity is 1·0242, and the refractive index 1·53212.

Phenyl methyl carbinol.

$$\begin{matrix} C_6H_5 \\ CH_3 \end{matrix} > CHOH$$

This has been found as an acetic ester in oil of gardenia; it boils at 203°.

Cinnamic alcohol :—$C_6H_5 \cdot CH : CH \cdot CH_2OH$

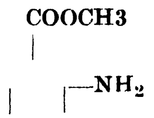
This substance occurs in the free state and as esters in various balsams of Peru and Tolu, and is largely manufactured by the reduction of cinnamic aldehyde. It is a beautiful crystalline substance possessing a delicate, very persistent, odour reminiscent of roses and hyacinths. It melts at 33°, the boiling point is 258° under 760 mm., the specific gravity is 1·01 to 1·03 at 35°, and the refractive index is 10·3024 at 25° (superfused).

Phenyl propyl alcohol: –
$C_6H_5{\cdot}CH_2{\cdot}CH_2{\cdot}CH_2OH$

This has been found as the acetic ester in cassia oil, and as the cinnamic ester in storax. It is a thick oil with an odour similar to cinnamic alcohol; it boils at 235° under 760 mm., the specific gravity is 1·007 and the refractive index 1·5283 at 20°C.

In considering the esters, it will be difficult to maintain a proper classification, as they are extremely varied, but the attempt will be made to deal with them in the same order as the alcohols.

Methyl anthranilate :—



This is the methyl ester of ortho amido benzoic acid.

It was discovered in neroli oil, and has also been found in numerous other flower oils, such as tuberose, ylang ylang, jasmin and gardenia. It has a very powerful odour similar to that of oil of neroli, and is manufactured on a large scale for use as a perfume material; when pure it is a white crystalline substance melting at 24° to 25°, and boiling at 132° under 14 mm. pressure, whilst the specific gravity is 1·168 at 15°, with the material in the superfused condition. Its solutions have a beautiful blue fluorescence which is apparent in all the oils containing it. It gives with para dimethyl-amino-benzaldehyde in the presence of alcohol, a cinnabar red substance which crystallised from alcohol melts at 181°.

The methyl ester of methyl anthranilic acid - –

$$C_6H_4\begin{smallmatrix}\diagup NHCH_3\\ \diagdown COOCH_3\end{smallmatrix}$$

Has been found to the extent of 1·5 per cent. in oil of mandarins, and also in the oils of rue and orange blossoms. It is an oily liquid with a sweet odour resembling oranges; when cooled it crystallises and then melts at about 19°, it boils at 130° under 13 mm., the specific gravity is 1·1238 at 20°, and its solutions show a fine blue fluorescence.

Methyl benzoate :—$C_6H_5{\cdot}COOCH_3$.

This highly odorous ester has been found in the oils of ylang ylang, tuberose and cloves, and it is also manufactured on a large scale under the name of Niobe oil. It is a liquid with a fragrant odour, boils at 199°, the specific gravity is 1·1026, and the refractive index 1·5170. The commercial article boils at 195°, and the gravity is about 1·103. This ester may be characterised by the crystalline compound which it forms with phosphoric acid as the benzoic esters of homologous alcohols form no such compound.

Methyl cinnamate :—
$C_6H_5{\cdot}CH{:}CH{\cdot}COOCH_3$.

Is found in various balsams and in the oil of Alpinia malaccensis, and is also made artificially.

It forms a low melting crystalline substance having the following characters :— it boils at 256° under 745 mm., and at 263° under 760 mm. the melting point is 34°—36°, the specific gravity is 1·0663 at 40°, and the refractive index is 1·56816 at 35°. The commercial article is generally in the form of an oily liquid having a penetrating fruity odour, and the compound is of considerable value in the perfuming of toilet articles.

Methyl phenyl acetate :—
$C_6H_5{\cdot}CH_2{\cdot}COOCH_3$

This ester has a powerful honey-like odour and is a liquid boiling at 220°. The ethyl ester boils at 226°, and the free phenyl acetic acid $C_6H_5{\cdot}CH_2{\cdot}COOH$, is a powerfully odorous crystalline substance melting at 76·5° and boiling at 262°.

Methyl salicylate :—

$$C_6H_4\begin{smallmatrix}\diagup OH\\ \diagdown COOCH_3\end{smallmatrix}$$

This ester is found in wintergreen leaves or in the sweet birch bark as an odourless glucoside called "gaultherin;" this glucoside decomposes under the influence of a ferment "betulase" setting free the methyl salicylate. For practical purposes, oil of winter green and oil of sweet birch are methyl salicylate, as they each contain about 99 per cent. of the ester. This substance is a colourless oil, having an intense wintergreen odour; it boils at 224°, has a specific gravity of 1·1819, and a refractive index of 1·5375. Much difficulty is experienced in distinguishing between natural oil of winter green and the artificial methyl salicylate and reference should be made to the *Jour. Amer. Chem. Soc.*, 1917, page 820.

Ethyl acetate.—$CH_3{\cdot}COOC_2H_5$

This occurs in the perfume of the magnolia. It is a liquid with a fruity odour, boils at 76, and has a specific gravity of 0·908.

Ethyl cinnamate :—

$C_6H_5 \cdot CH:CH \cdot COOC_2H_5$

It is found in camphor oil, storax, and in a few other essential oils, it has a pleasant odour and is a liquid boiling at 271° with a specific gravity of 1·0498 at 20°, and a refractive index of 1·5590 When cooled it crystallises and then melts at 12°.

In connection with the esters of isoamyl alcohol, there has recently been published an investigation as to the actual composition of the odorous constituents of apples and this has led to the publication by F. B. Power and V. K. Chestnut of a formula which will reproduce the true odour of apples in foods and beverages: the following esters are used and should be in the highest state of purity whilst the quantities are by volume :—

The iso amyl ester of formic acid 10 parts.

The iso amyl ester of acetic acid 10 parts.

The iso amyl ester of normal caproic acid 5 parts.

The iso amyl ester of normal caprylic acid 1 part.

Acetaldehyde 2 parts.

Hexyl acetate :—$CH_3 \cdot (CH_2)_5OOC \cdot CH_3$.

This ester occurs in the oil of heracleum giganteum, it has a fruity odour, boils at 169°, and has a specific gravity 0·890 at 10°.

Benzyl acetate :—$C_6H_5 \cdot CH_2 \cdot COOCH_3$

This has been found in the oils of jasmin, ylang ylang, and other flower oils, and although it has not a very intense odour, it is very important for the successful production of certain artificial floral perfumes; it is manufactured on a large scale and must always be examined for the presence of chlorine. When pure it is a colourless oil with a characteristic odour, it boils at 262°, the specific gravity is 1·057 and the refractive index is 1·5034. The commercial article generally falls within the following limits, the specific gravity 1·060-1·062, the refractive index 1·502-1·504, and it should contain at least 98 per cent. of esters and be soluble 1 in 6 or more of 60 per cent. alcohol.

Benzyl benzoate :—

$C_6H_5 \cdot CH_2 \cdot COOC_6H_5$

This is a constituent of Peru balsam and also occurs in the oils of tuberose and ylang ylang. It is manufactured on a considerable scale, partly for use as a solvent for artificial musk and partly as a diluent and a fixing agent for the more volatile essential oils. It has a slight sweet odour and gives a certain characteristic to blended perfumes. When absolutely pure it is a crystalline substance melting at 21° but, in general, it is a liquid, boils at 323°-324°, and has a specific gravity of 1·124 and a refractive index of 1·5681.

Benzyl cinnamate : –

$C_6H_5 \cdot CH_2OOC \cdot CH : CH \cdot C_6H_5$

This is a natural constituent of storax, and the balsams Tolu and Peru, it is a crystalline substance with a characteristic sweet balsamic odour, it melts at 39° and decomposes at about 350°, the best commercial specimens melt at 31°-33·5°, and contain from 96-98 per cent. of the true ester. Space does not permit of any further treatment of the ester group.

The Fatty Aldehydes.

Iso-amyl aldehyde :—

$(CH_3)_2CH \cdot CH_2 \cdot CHO$

This has been found in sandalwood oil and is a liquid with a fruity odour, boils at 92·5°, and has a specific gravity of 0·8040 at 15°. It has been identified by means of its thio-semicarbazone, which melts at 52·5°.

Nonylic aldehyde :—$C_9H_{18}O$

Has been found in rose, orris, cinnamon, mandarin and lemon oils, it is a liquid, boiling at 80°-82° under 13 mm., and on cooling crystallises and then melts at 5°-7°, the specific gravity is 0·8277 and the refractive index is 1·42452.

Decylic aldehyde :– $C_{10}H_{20}O$

This has been found in orris, mandarin, neroli and other oils, it is a liquid boiling at 97°-98° under 15 mm., and at 207°-209° under 755 mm., and the specific gravity is 0·828-0·836, and the refractive index 1·4273-1·42977.

Duodecylic aldehyde or lauric aldehyde :– –

$C_{12}H_{24}O$

Has been found in the pine needle oil from Abies pectinata, it is of special value when used together with the ionones. When added to α ionone in the proportion of 5 per cent. or to β ionone in the proportion of 10 per cent., it is stated to produce a highly natural violet perfume mixture. The aldehyde crystallises in leaflets melting at 44·5°, and it boils at 142°-143° under 22 mm.

The above aldehydes are somewhat difficult to prepare and especially to preserve and use, but together with others which do not occur in essential oils, they have a great tendency to polymerise, and are usually

kept in 5 to 10 per cent. absolute alcohol solutions in fully filled bottles and in the dark.

The aromatic aldehydes.

The most important of these is :—

Benzaldehyde :—$C_6H_5 \cdot CHO$

This occurs in various seeds such as bitter almonds, and the seeds of the apricot and the peach. It is present in the form of a crystalline glucoside "amygdalin," which can be hydrolised by the enzyme ferment "emulsin" the products of reaction being glucose, prussic acid, and benzaldehyde. The natural benzaldehyde may contain traces of prussic acid, but most of the benzaldehyde of commerce is made artificially and is a colourless to pale yellow liquid boiling at 178° and having a specific gravity of 1·050 and a refractive index of 1·5450.

Cinnamic aldehyde :—

$$C_6H_5 \cdot CH : CH \cdot CHO$$

This is found in the cassia oil which is derived from the leaves, leaf-stalks and young twigs of Cinnamomum cassia. The oil contains from 75 to 90 per cent. of cinnamic aldehyde and small quantities of cinnamyl acetate and beta-methoxy coumaric aldehyde. True oil of cinnamon called "Ceylon oil" is derived from the bark of the cinnamon tree. Cinnamomum zeylanicum also contains the aldehyde to the extent of 65 to 75 per cent. Often the leaves are distilled with the bark causing the oil of cinnamon to contain much eugenol, there has been detected in cinnamon oil such substances as pinene, phellandrene, cymene, eugenol, and the aldehydes benzoic, nonylic and hydrocinnamic, in addition to furfurol and linalol. It should be mentioned that the oil derived from the cinnamon root contains eugenol, safrol, camphor, benzaldehyde and esters of benzoic acid. Pure cinnamic aldehyde is a colourless to yellow, oily liquid, having a characteristic odour. It boils with decomposition from 247°-252°, the specific gravity is 1·054-1·058, and the refractive index is 1·6195.

Ortho-methoxy cinnamic aldehyde :—

$$C_6H_4 \begin{matrix} \diagup OCH_3 \\ \diagdown CH : CH \cdot CHO \end{matrix}$$

This has been found in cassia oil as a yellow crystalline compound melting at 45° and boiling at 295°. The para isomer is a constituent of estragon oil, it boils at 170° under 14 mm. and has the specific gravity 0·137.

Cumic aldehyde : or isopropyl benzaldehyde :—

$$C_6H_4 \begin{matrix} \diagup C_3H_7 \\ \diagdown CHO \end{matrix}$$

This has been found in cumin, baldo leaf, cassie flower and certain eucalyptus oils, it is a powerfully odorous liquid boiling at 235·5° and it has a specific gravity of 0·982.

Salicylic aldehyde :—

$$C_6H_4 \begin{matrix} \diagup CHO\ (1) \\ \ OH\ (2) \end{matrix}$$

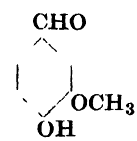
Has been found in the oils of the spiroea family and is also prepared artificially. It is an almost colourless fragrant oil, having the odour of meadowsweet, it boils at 197° and has a specific gravity of 1·1731.

Anisic aldehyde :—

$$C_6H_4 \begin{matrix} \diagup CHO\ (1) \\ \diagdown OCH_3\ (4) \end{matrix}$$

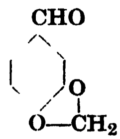
It is a natural constituent of oil of aniseed and fennel oil and is prepared on a large scale, and also obtained as a by-product from the manufacture of coumarin. It is a liquid boiling at 246°, the specific gravity is 1·126-1·129 and the refractive index is 1·5725.

Vanillin—the methyl ester of protocatechuic aldehyde.



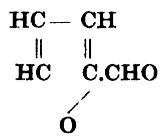
This very important substance is found in the vanilla pod, and the vanilla of commerce is the dried and prepared pod of several varieties of a climbing orchid, of these there are eight well-known varieties that produce marketable pods, of which five are found in Java; probably the three best known are Vanilla planifolia, V. sylvatica and V. pompona. The vanilla plant is a native of Central and South America and is cultivated in Mexico, Brazil, Honduras, Guadeloupe Réunion, Mauritius, the Seychelles, Java, Tahiti, the South Sea Islands, Polynesia and in Tropical Queensland. The beans undergo a special treatment which brings about the formation of the vanillin. The artificial production of vanillin was one of the triumphs of organic chemistry so far as the perfume industry is concerned and to-day scores of processes are known whereby it can be formed. It is largely made from eugenol, a phenol found in oil of cloves, etc. When pure, vanillin forms white crystals which melt at 81°-82°, and distilled in a current of carbon dioxide, it boils at about 285°.

Heliotropin or piperonal or the methylene ether of protocatechuic aldehyde.

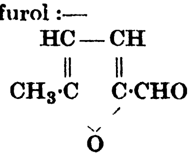


This occurs in certain varieties of vanilla and also in oil of spiroea and can be made from the alkaloid piperine which occurs in pepper but is always manufactured from safrol. It is a white crystalline substance melting at 37° and boiling at 265°. It is curious to record that although it is an aldehyde, it does not reduce silver nitrate solution.

Furfurol :—



This is an aldehyde of rather special constitution, it is found in many essential oils, such as ambrette, East Indian sandalwood, petitgrain, clove, vetiver and many others, and is generally accompanied by traces of methyl alcohol and diacetyl. It is a liquid boiling at 160·5° under 742 mm., and has a specific gravity of 1·594. α methyl furfurol :—

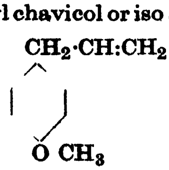


has been found in clove oil and is a liquid boiling at 185°.

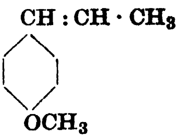
The phenols and their derivatives.

Of the many phenolic compounds which occur in essential oils, those containing either the allyl or the propenyl group are of special interest. No attempt will be made to arrange these phenols in any particular order, but for reasons which will be apparent later the first phenol to be dealt with is :—

Estragol—methyl chavicol or iso anethol:—

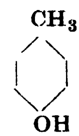


This para-methoxy-allyl-benzene occurs in chervil and basil oils, whilst the isomeric :—anethol or para-methoxy-propenyl-benzene



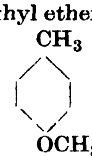
is an important constituent of aniseed oil. In reality, estragol is changed into anethol by boiling with alcoholic potash, and it must be remarked that this isomeric change is of enormous technical importance in connection with the manufacture of vanillin from eugenol and of heliotropin from safrol.

Para-Cresol :—



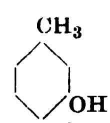
This substance is found in the oils of cassie and jasmin, it is a crystalline compound melting at 36° and boiling at 199°.

Para-Cresol methyl ether :—



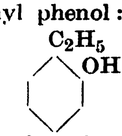
occurs in ylang ylang oil, it is a liquid boiling at 176·5° and has a specific gravity of 0·9757 and is manufactured artificially for use in perfumery.

Meta-Cresol :—



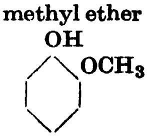
Has been found in myrrh oil and is a liquid boiling at 201°.

Phlorol or ethyl phenol :—



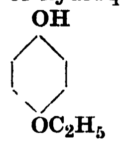
It occurs in oil of arnica as an isobutyl ether and is a liquid boiling at 226°.

Guaiacol or the methyl ether of catechol:—



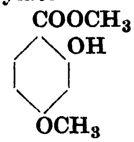
This monomethyl ether of ortho-dihydroxybenzene has been found in celery oil. It possesses a very characteristic odour, and when pure is a crystalline substance melting at about 33°, but the commercial article is frequently liquid, and boils at 200°. This guaiacol is a raw material for the manufacture of vanillin and some of its compounds are of considerable medicinal interest.

The ethyl ether of hydroquinone :—



This has been isolated from star anise oil and forms colourless pearly needles, which melt at 64°.

Methoxy-methyl-salicylate or p-methoxy-beta-methyl-resorcylate :—



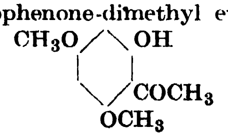
This has been called "primula camphor" and is contained in the essential oil of primula; it is a crystalline substance melting at 49°.

The Dimethyl ether of pyrogallol :-

$C_6H_3(OH)(OCH_3)_2$

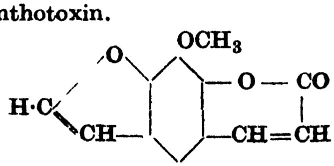
This has been isolated from schei oil, it is crystalline and melts at 51°.

Phloracetophenone-dimethyl ether :—

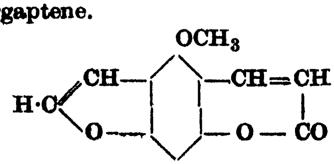


This substance has been isolated from "Ngai camphor," which is obtained by distillation from the plant Blumea balsamifera and has also been found in the oil from Xanthoxylum Aubertia. At this point mention should be made that Thoms, whilst investigating the root oil of Fagara xanthoxyloides, extracted from the shells a solid substance melting at about 128°, from which two substances were isolated, *e.g.*, Xanthotoxin, a powerful fish poison, melting at about 146°, and Bergaptene, melting at about 191°, this latter is also an important constituent of bergamot oil. The two substances are isomeric, but whilst xanthotoxin is a derivative of pyrogallol, the bergaptene is a derivative of phloroglucinol :—

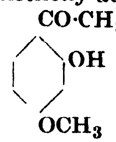
Xanthotoxin.



Bergaptene.

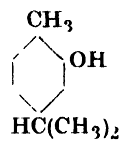


Paenol or oxy-methoxy-acetophenone :—

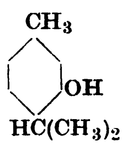


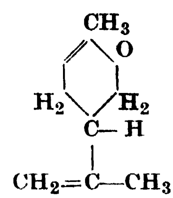
This is found in the root of Paeonia Montana, as a glucoside, which on hydrolysis gives the paeonol as a crystalline substance with an aromatic odour and melting at 50°.

Carvacrol :—



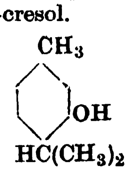
This is isomeric with thymol and carvone :—





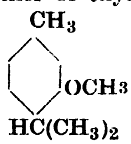
It has been found in the oils of origanum hirtum and Saturega hortensis and in wild bergamot, whilst Crete origanum oil contains about 55 per cent. of this phenol. It is a thick liquid boiling at 237°, the specific gravity is 0.980, and on cooling it crystallises and then has a melting point of 0·5°. Although it resembles thymol it can be distinguished therefrom by its alcoholic solution giving a green colouration with ferric chloride, whilst thymol gives no colouration. The phthalein of carvacrol can be used as an indicator giving a deep blue colour, and, further, has a purgative action similar to phenolphthalein.

Thymol, methyl-iso-propyl phenol or iso-propyl-meta-cresol.



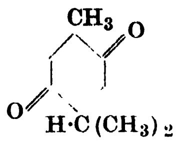
This important and valuable substance occurs in oil of thyme to the extent of about 20 per cent. and in ajowan oil to the extent of 40-55 per cent. From such oils the thymol is isolated and this industry is now well established in this country. It forms large white crystals, which melt at about 51° and boil at about 234°, its powerful antiseptic and germicidal properties render it of great value.

The methyl ether of thymol :—



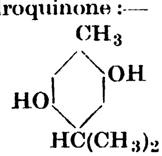
Is found to the extent of about 10 per cent. in sampline oil and in the oil from crithmum maritimum, it is a liquid boiling at 217° and having a gravity of 0·954 at 4°.

Thymoquinone :—



This has been isolated from the oil of wild bergamot (Monarda fistulosa) and also in thuya articulati, and is generally associated with thymo-hydroquinone. It is a crystalline substance melting at 48°.

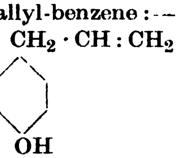
Thymo-hydroquinone :—



Is a constituent of wild bergamot and Algerian fennel oils, and forms colourless crystals melting at 145° and boiling at 290°

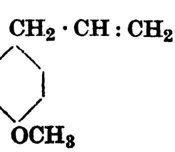
The dimethyl ether of thymo-hydroquinone. This occurs in oil of arnica root as a liquid boiling at 248°-250° and with a gravity of 0·9913 at 20°.

Chavicol, p-oxy-allyl-benzene :—



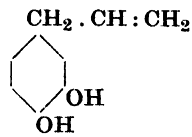
Is a constituent of the essential oils of bay and betel, and is a liquid boiling at 237° with a gravity of 1·033.

Estragol or methyl chavicol or iso-anethol :—



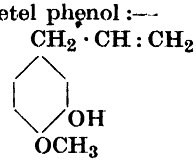
Has been mentioned before and is found in estragon, chervil and basil oils, it is a liquid having a characteristic anise odour, boils at 216° and has a specific gravity of 0·9663 at 15° and a refractive index of 1·51966 at 20°. The estragon oil is used in the manufacture of mustards, relish sauces, and table vinegars and for various culinary purposes.

Allyl pyrocatechol :—



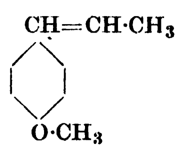
Has been identified together with chavibetol in Java betel oil, it is a crystalline compound with an odour resembling creosote and melts at 49°.

Chavibetol or betel phenol :—



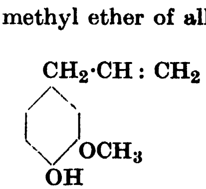
Is found as mentioned above and is an oil having the characterisitc betel odour, it boils at 255° and has a gravity of 1·069.

Anethol, the methyl ether of p-propenyl benzene :—



This is an important constituent of aniseed and fennel oils, whilst star anise oil contains it to the extent of about 80 per cent. It forms white crystals which melt about 23° and have a congealing point of 21°-22°, and the boiling point is 235°, whilst the specific gravity is 0·984-986 at 25°.

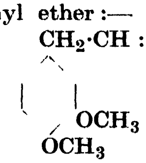
Eugenol, the methyl ether of allyl dioxy-benzene :—



This is a constituent of oil of cloves in which it occurs to the extent of 85-95 per cent., and it is also found in the oils of allspice, bay and cinnamon leaves. The phenol has beren found in *Geum urbanum* in the form of a glucoside "Geine," which can be split by the ferment "Gease" which is found in the same plant. Much eugenol is manufactured from oil of cloves

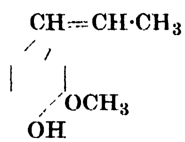
and is a colourless liquid with a characteristic clove odour, boils at 248°, the gravity is 1·072 and the refractive index 1·5439. It is the raw material for making vanillin, and is much used as an antiseptic.

Eugenol methyl ether:—



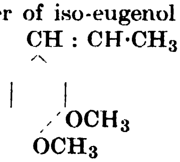
Is a constituent of the oils of Evodia simplex, cassie, ylang ylang, citronella, and Canadian snake root. It is a liquid with a clove odour, boils at 249°, the gravity is 1·055, and the refractive index 1·5373.

Iso-eugenol: –



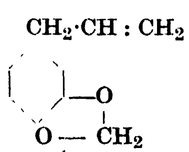
Is a constituent of nutmeg and ylang ylang oils, and is prepared on a large scale from eugenol. As ordinarily prepared, it is a liquid with odour reminiscent of cloves and carnations, it boils at 261° and has a gravity of 1·090 and a refractive index of 1·5680—1·5728. When sunlight acts upon iso eugenol dissolved in alcohol containing hydrochloric acid, a polymerisation into a crystalline substance di-isoeugenol melting at 180°, takes place.

The methyl ether of iso-eugenol: –



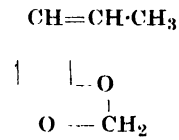
This is a constituent of the oil of asarum arifolium, and is a liquid boiling at 263°.

Safrol, the methylene ether of allyl dioxybenzene:—



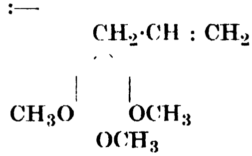
This is found in Japanese star anise oil from the fruit of Ilicium Religiosum, and it must be pointed out that this oil differs from the Chinese star anise oil as it only contains a trace of anethol mixed with the safrol. Safrol is also found in sassafras oil, but is manufactured on a very large scale from camphor oil to serve as the raw material for making heliotropin. It is a liquid boiling at 233°, the specific gravity is 1·106, the refractive index is 1·5380.

Iso-safrol, the methylene ether of propenyl diozybenzene: –



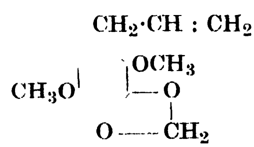
It is a constituent of ylang ylang oil, but is manufactured by the isomerisation of safrol and by a simple series of reactions is converted into heliotropin. It is a liquid boiling at 254°, the gravity is 1·127 and the refractive index is 1·5800.

Elemicine:—



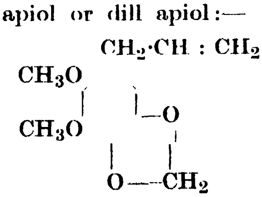
Has been isolated from manilla elemi oil, and is a liquid boiling at 144°–147° under 10 mm., and has a density 1·063 at 20°.

Apiol: –



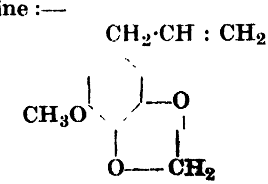
Is a constituent of German oil of parsley seed, and is also found in Matico oil; it is crystalline, melts at 30° and boils at 294° under 760 mm.

Anethol apiol or dill apiol:—



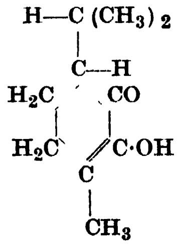
This occurs in Matico oil and is a liquid boiling with decomposition at 285°.

Myristicine:—



This is a constituent of nutmeg parsley and certain other oils, it boils at 149·5° under 15mm., and the gravity is 1·1425 at 19°.

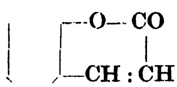
Diosphenol :—



It has been stated that Buchu oil consists of two main constituents, the solid diosphenol and a liquid. Diosphenol is crystalline, melts at 83°—84° and boils at 109°—110° under 10 mm.

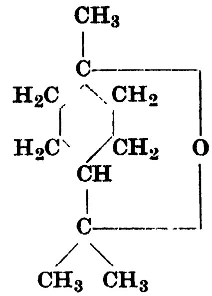
Heterogeneous Compounds.

Coumarin : —



This is found naturally in many plants, though it is well-known that such plants do not exhale the odour when fresh and unbruised. When dried or injured, the odour becomes apparent and this is the case with all the coumarin-producing plants such as Anthoxanthum odoratum, the sweet-scented vernal grass and other grasses which impart the characteristic odour to hay. It is also found in the Laitris odoratissima and Laitris spicata or deer's tongue and in the Angraecum Fragrans, Melilotus fragrans and Asperula odorata, or Woodruff. The chief natural form of coumarin is the Tonco, Tonka or Tonquin bean, and these are the seeds of the Dipteryx odorata. The real sources of the bean are the tropical countries of South America, principally in the valleys of the Orinoco, Caura, and Cuchivero rivers of Venezuela and in parts of Colombia. In Venezuela the centre of the industry is Ciudad Bolivar. The seeds require treatment in order to bring about the formation of coumarin; actually about 3 per cent. of coumarin is contained in the bean. Much coumarin is made with salicylic aldehyde as the starting material and the manufacture of this aldehyde is not very easy. Pure coumarin forms colourless crystals melting at 68° and boiling at 289.°

Cineol or eucalyptol :—



This very important substance is found in considerable quantity in the oils of Cajuput, Eucalyptus and wormseed and also in smaller quantities in the oils of camphor, cinnamon, lavender, laurel rosemary, sage and spike. It is a liquid boiling at 176° and having a specific gravity of 0·928 to 0·930, and a refractive index of 1·458-1·459. It forms compounds with several widely different substances, such as arsenic acid, phosphoric acid, resorcinol, and ortho cresol, from this last cresineol is obtained.

Ascaridol $C_{10}H_{16}O_2$.

This substance is allied to cineol and is found in the oil of Chenopodium to the extent of about 70 per cent., it is a liquid boiling at 80°-84° under 5 mm. pressure and decomposes violently on heating to 130°-150°, becoming a paraffin hydrocarbon, it has a specific gravity of 1·008, a refractive index of 1·474, and an optical rotation of − 4° to − 5°.

Of the compounds containing nitrogen which occur in essential oils, hydrocyanic acid is the simplest. This acid is found, together with benzaldehyde, in the oils of almonds, cherry-laurel and wild cherry bark, and its properties are too well-known to be mentioned here.

Allyl cyanide :—$CH_3 \cdot CH : CH \cdot CN$

This has been discovered in the essential oils of mustard and horseradish, it is a liquid boiling at 120°-123°. The nitrile of phenyl acetic acid $C_6H_5CH_2CN$ boils at 231·5 and has been found in the oils of Tropaeolum majus and Lepidium sativum, whilst the nitrile of phenyl propionic acid, $C_6H_5CH_2CH_2CN$, boiling at 261°, is a constituent of nasturtium oil.

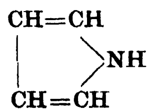
Some very volatile nitrogen and sulphur compounds such as ammonia and trimethylamine, are sometimes produced during the distillation of certain essential oils and sulphuretted hydrogen is always formed

during the steam distillation of caraway seeds.

Oil of black mustard contains carbon disulphide and American peppermint dimethyl sulphide, whilst allyl sulphide is a constituent of oil of garlic.

Allyl iso-thio-cyanate, $C_6H_5 \cdot N:C:S$, is an important constituent of mustard oil, and is formed by the decomposition of a glucoside, it is also made artificially and is a liquid boiling at 151°. Several similar compounds are found in the oils of the mustard family.

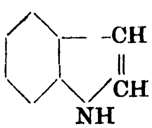
A compound of quite a different character viz., pyrrol,



is found in Paraguay petitgrain oil and is a liquid boiling at 131°.

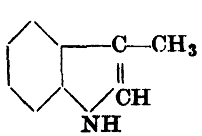
Pyridine has been isolated from the oil from roasted coffee.

Indol :—



This is known to be a constituent of the oils of neroli and jasmin, and is present in the odorous emanations from many members of the citrus genus and other flowers. The following test will show the presence of indol in flowers :—Cotton wool, soaked in a saturated solution of oxalic acid is placed on the bottom of a covered glass vessel and a clock glass containing the fresh flowers is placed on this. The cover is securely fixed on the apparatus, allowed to stand in the light for 24 hours. In the presence of indol parts of the cotton will show a violet to reddish shade. In another test, a filter paper moistened with a solution of vanillin in a mixture of strong hydrochloric acid and alcohol is suspended in contact with the vapours from the flowers, when traces of indol cause a violet colouration, and this test also detects skatol. Indol melts at 52°, boils at 254° and has a disagreeable smell.

Skatol :—



This β methyl indol occurs in certain woods, such as celtis, reticulosa. It has a most offensive smell, is crystalline, melts at 95° and boils at 265°.

In recent years it has been obvious that research in every direction has been actively in progress and whilst much work has been done of a rather academic character, on the terpene derivatives, there has been a distinct advance in our knowledge of the constitutents of essential oils. Much work has been done on the manufacture of purely synthetic odorous substances, such as phenyl acetaldehyde, and the ionones, whilst the art of sophistication has not been neglected, and the analyst is required to be continually alert. The application of optical methods, such as the measurement of rotations and indices of refraction, has been more and more utilised, and the data therefrom have rendered the path of the adulterator exceedingly difficult. In connection with this industry at home, the manufacture of flavouring esters has been well developed, but much remains to be done in insuring the absolute uniformity of the products offered as this is of paramount importance to the user, who has to produce comestibles always of uniform odour and taste. Once again emphasis must be placed on the necessity for producing the widest possible range of substances used in the perfume industry and manufacturers now in the front rank must see that their analysts do not allow any product to pass from their works to the consumer without the certainty that the product is as pure as they represent it to be ; a few careless mishaps can do untold harm to this rising industry.

The Empire contains within its confines such varieties of climate and soil that it is quite possible for it to provide every kind of raw material and essential oil, and the Colonies, etc., should be urged and helped in every possible way to develop to the fullest extent their present resources, and to experiment with the introduction of plants suitable to their particular district. There can be no doubt that by a proper survey of the Empire's resources, carried out in a thorough manner, it will be discovered that the British Empire alone is able to provide British manufacturers with all the materials they need for a successful essential oil industry, and all the ramifications therefrom, and, further, our young chemists must have brought before them the importance of this branch of chemical industry. There already exists an ably conducted Journal, *The Perfumery and*

Essential Oil Record, entirely devoted to this industry, and this should be supported in every possible way, and the researches should be as far as possible published in such a special organ, as the scattering of publication does not conduce to strength; and, further, the industry should combine to form a research association, governed by thoroughly competent members of firms already engaged in the industry, and this association should obtain the power which will enable it to approach the Government as an authoritative body on every matter connected with every branch of this great industry.

NOTES ON BOOKS.

RADIO-ACTIVITY AND RADIO-ACTIVE SUBSTANCES. By J. Chadwick, 1921.
FILTRATION. By T. Roland Wollaston. 1922.
INDUSTRIAL NITROGEN. By P. H. S. Kempton. 1922. These form part of Pitman's series of Technical Primers. 2*s.* 6*d* each, net. London: Sir Isaac Pitman and Sons, Ltd.

Radio-activity and radio-active substances as a title for a technical primer, leads us to expect a study of applied or industrial aspects; as, for example, the associated radium salt and zinc sulphide, or like preparations, which did us such good service during the war as a means of locating positions in darkness, the use of radium for stemming malignant degenerations of tissue, also other medical applications, various amplifiers or devices that render trans-atlantic telephony possible and which are directly or indirectly consequent on researches as to radio-activity, the use of the natural stock of the outcome gas helium in aerostation, and, indeed, many other applications actual or in prospect.

The long sub-title and the preface, however, prepare us for a theoretical treatise, mainly on the nuclear aspect of the atom.

Figure 2 on p. 7, gives, it is said, "a rough idea of the general build of the nucleus atom," and the figure rather suggests a solar system with eleven planets in two circular orbits, but we are uncertain as to the author's views on the vexed question of rotation. Nevertheless, we are confidently told (p. 6) that "since the atom, as a whole, is neutral, there must be a positive charge associated with the atom, equal in amount to the sum of the negative charges"; this being repeated with slight variation on p. 7.

Attractive as this concise dictum may appear to some, we may suggest that an exactly balanced polarity, or neutral condition of each atom, is merely a conjecture; indeed, a conjecture based on the conjecture that atoms exist as such. Admitting both conjectures to be true, speculations regarding electrical or other equilibrium should include a consideration of conditions like those touched on by Sir J. J. Thomson in NATURE, November 6th, 1919, p. 225; especially as to the inter-relations of mass and charge, mass and velocity; also Thomson's view that in matters of atomic equilibrium the rule of inverse squares does not always hold good, and we may have a change from attraction to repulsion at definite distances. Mention may be made of Professor Harkins's letter in NATURE of April 22nd, 1920, and the list of references which he gives. The reader of the book under notice will realise that the somewhat various and nebulous conjectures of the present time tend towards replacing the ancient doctrine of a protyle by a view that the fundamental physical constituents are two, and when associated they give rise to the Daltonian combining units, groups, or perhaps better "atomoids."

"Filtration" is eminently practical, thorough and clearly expressed. The author, by a judicious economy of words, and the avoidance of all superfluities, makes it a good first text-book as regards water purification, as also testing, and the drawings af the essential features of representative filtration systems are admirable. Mr Wollaston includes the essential facts as regards filter-presses, centrifuges, oil filters, spray screens for air filtration, and the means of bringing about an electro-static deposition of dust. Like all good technical books, Mr. Wollaston's primer is virtually much more comprehensive than in actual fact, by reason of the many references in the text, and a thoughtfully considered bibliography.

"Industrial Nitrogen" is, in the main, a booklet on the methods of converting atmospheric nitrogen into industrially serviceable products; as nitrates, ammonia, or cyanogen compounds, and the general reader may gather from it many interesting first notions. There appears to have been a somewhat hasty reading of the proofs: hence there is not in every case that strict and exact relation between chemical words and their meanings, which is so essential to the making of a satisfactory technical primer. Thus "Chile saltpetre" (p. 7) is not ideal as the commercial name of potassium nitrate, and on p. 84, there is a tabulation of aniline colours, but chemical names, as given, would be the better for revision. For example, pararosaniline is not magenta, in the strict sense of the term, but a colourless substance which may yield a magenta.

DESIGN OF THE SENTENCE FOR TECHNICAL USE.

A comparative study of the three technical primers from the standpoint of that art of arts, the exact use of words and phrases, may be opportune.

Mr. Wollaston's book on filtration appears to us to be the work of one who takes a keen personal interest in language, and as an outcome of this interest he contrives to make his sentences and meanings clear and definite, without any appearance of pedantry.

Mr. Kempton is at times notably metaphorical; for example, on p. 10 he refers to "harnessing this inert chemical monster nitrogen to the chariots of war," and the word "key" figures rather obtrusively and variously as a simile. In the figurative sense Mr. Kempton appears to recognise several master keys, as he terms nitric acid "one of the master keys to the materials of our modern civilisation" (p. 62).

Dr. Chadwick may have been influenced by the publisher's announcement as to the usefulness of the series to "the busy practical man," and in striving towards adaptation to this standard, he appears to have drifted too deeply into that language of London's busy artificers, and of a growing school of metropolitan newspaper reporters, which is commonly known as the dialect of London; one characteristic being a loss of nearly all the old preterite and aorist forms, many of which are still fully current in the Midlands and Northward (see p. 26 of MacBride's "London's Dialect," Priory Press, Hampstead, 1910). Imperfect past forms, repeated or multiplied in the same period or sentence sometimes give to that which ought to be a gnomic aorist, an aspect which to the serious student may appear to be something beyond a pluperfect: thus a well-meant effort to make matters clear to those of immature scholarship may mislead those of riper scholarship; unless the reader happens to have such previous knowledge of the laboratory facts, as may cause him unconsciously (or by a kind of reflex action) to adjust himself to the vague or non-lucid language.

For example, on p. 1 of Dr. Chadwick's book he tells us that "——— uranium salts emitted spontaneously a radiation which was capable ———," and that "———radiation from uranium also possessed the property ———." The full text of these sentences taken literally suggests that the emissive quality is a transient condition which merely held good when Becquerel made his observations, but the actual fact is otherwise; the emissive condition being independent of temperature, pressure, chemical stress or anything even remotely analogous to spontaneity, contingent action, or freewill; indeed, depending on an immanent property of uranium, effective as regards past, present and future; or as long as any trace of the original uranium remains.

During some three thousand years it has been a custom of plain non-emotional or non-poetical writers to use the present tense of the verb to express the sense of the gnomic aorist or the aorist indicative: and this quite irrespective of the existence or non-existence of definite aorist forms in the language used. Much may be said in favour of this concise and usually lucid mode of expression. Harris (Hermes, 5th edition, London, 1794, p. 124) illustrates its application to verse by quoting Milton's line:—

"Millions of spiritual creatures walk the earth."

That is to say they walked, walk now, and will walk. The alternative course, or use of many finely adjusted and well-considered augments to the conjugations of the verbs is touched upon by Breal (Semantics, Mrs. Cust's English version. Heinemann, 1900, p. 75); not in relation to any question of convenience in respect to modern use, but rather as illustrating the intelligence of the Athenian masses "in overcoming difficulties which, in every art, the material opposes to the workman."

Metaphor and what one may term literary decorations of the florid kind, appear to be for the most part incongruous in technical and scientific writings much in the sense that the "Fine Art Microscope" of Messrs, Parkes and Son, shown in the Exhibition of 1862 (figure of Dolphin, or like, embodied in the stand of a microscope) was denounced by the jurors as "an incongruous and uncommendable monstrosity" (Juror's reports, issued by the Society of Arts, Class XIII. p. 23). In connection with this view it is interesting to note that the immortal master of metaphor, Milton, in his History of Britain, adopts a rigidly plain style, but so perfect as regard lucidity and the grammatical forms, that should the time ever come for a detailed study of the design of the sentence as adapted to technical and scientific use, this work may be of material use as a first pattern.

THE EMBROIDERY AND DRAWN WORK INDUSTRY OF THE CANARY ISLANDS.

The embroidery and drawn-work industry of the Canaries, though not a very important one, holds an interesting position in the trade of the islands. Teneriffe embroidery has been known widely for many years and there is a constant, though small demand, for it. Local statistics show that 113,935 pounds of embroideries, drawn work, and lace were shipped to 15 countries in 1920.

All this work, writes the United States Vice-Consul at Teneriffe, is done by hand and is undertaken by women in their homes in the same manner as the lace industry is carried on in Belgium. The larger part of the work is done on orders received by firms specialising in the placing of orders locally and the shipping of the manufactured articles to the purchaser. These jobbers distribute the work among the women, furnishing them with the necessary cloth and thread, and sometimes also with the design, paying them for their labour.

Apparently the commission charged by these jobbers is quite reasonable, as this method of doing business seems to be satisfactory to the foreign importer.

The cloth used ranges from all cotton to cotton and linen, pure linen, and silk. Barcelona supplies most of the cotton cloth; the cotton-linen, all-linen, and silk cloths largely come from Great Britain. Formerly Belgium was the chief supplier of pure linen cloth. Cotton thread is used and is brought from Barcelona, Great Britain, and Mulhouse (Alsace-Lorraine), though imports from the last named centre have declined considerably since the war.

The industry comprises three distinct kinds of work: embroidery, which consists of designs worked on cotton, linen, or silk cloth; drawn work, which consists in drawing threads out of the cloth and, with a needle, working in a sort of lace in the space left; and lace, which is made on a small cushion by hand. (No machine-made lace is produced in these islands.) The embroidery work is done in the island of La Palma, the drawn work in Teneriffe, and the lace in Lanzarote. Orders are usually placed in the spring and summer, so that the work may be completed by autumn, the best season for selling these articles in the northern countries. There is no standard price for the finished pieces; when orders are scarce prices are lowered to attract buyers, and when orders are plentiful prices rise accordingly.

UTILISATION OF COAL WASTE ON GERMAN RAILWAYS.

Germany's greatest user of coal is the Federal Railway, which formerly was able to utilise only 55 to 70 per cent. of its combustible material, the remainder (cinder and ashes) having been regarded as worthless. In order to make use of this waste, which is said to contain 50 per cent. or more combustible material, about two years ago the railway adopted the Meguin system of recovering coal from ashes. According to a report by the United States Consul at Frankfort on Main, thirteen large works, with a capacity for handling 420,000 tons of cinders and ashes annually, are now in operation or under construction. The amount of pure coke obtained is estimated at 164,000 tons, with an average calorific value of 5,500 units, compared with 7,000 units for good hard coal.

The fine coke, with the addition of fine coal and hard pitch, is used in making briquettes, about 74,000 tons of coke briquettes being thus obtained, with a calorific value of 6,500 units. In addition to this, 256,000 tons of non-combustible clean slag are obtained; this serves for the manufacture of 130,000,000 slag stones, which are employed in building and possess the good qualities of both brick and "schwemmstein" (a kind of sandstone).

*MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 6 .. University of London, at the London School of Economics, Houghton Street, Aldwych, W.C., 5 p.m. Prof. Eugene Borel, "The Position of Switzerland in International Law."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Opening Address by the President.

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Street, Victoria Embankment W.C., 5.30 p.m. Sir William Acworth, "British Railway Operating Statistics and their Lessons."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m., Mr. E. E. Turner, "The Atlantic Cruise of H.M. Airship R. 34."

Chemical Industry, Society of (London Section), at the Engineers' Club, 39, Coventry Street, W., 8 p.m. Dr. E. F. Armstrong, "Some Problems in Chemical Industry."

TUESDAY, NOVEMBER 7 .. Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. Address by the President, Dr. W. H. Maw.

Metals, Institute of (Birmingham Section), Chamber of Commerce, New Street, Birmingham, 7 p.m. Mr. W. R. Barclay, "Nickel, its Properties and Uses."

Alpine Club, 23, Savile Row, W., 8.30 p.m. Brig.-General the Hon. C. G. Bruce, "Outline of the 1922 Everest Expedition."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Prof. Sir Arthur Keith, "An Account of Mr. G. Despott's Excavation of the Cave of Ghar Dalam, Malta, and an Exhibit of two teeth of Neanderthal Man found there."

WEDNESDAY, NOVEMBER 8 .. Geological Society, Burlington House, Piccadilly, W., 8 p.m.

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. H. H. Elvin, "Education as a Function of Management."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Mrs. Margaret Rorke, "The Problem of the Syphilitic Child."

Botanic Society, Regent's Park, N.W., 3 p.m. Prof. R. R. Gates, "Modern Advances in Genetics."

St. Paul's Ecclesiological Society, 7, St. Andrews Street, Holborn, E.C., 8 p.m. Mr. P. M. Johnstone, "Romanesque Architecture in the South Western Counties."

Metals, Institute of (N.E. Coast Section), Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Mr. O. Smalley, "Moulding Sands." (Joint meeting with the Institute of British Foundrymen.)

University of London, University College, Gower Street, W.C., 6.15 p.m. Mr. A. W. Flux, "Foreign Exchanges: Effects of War on the Exchanges. The Balancing of International Payments." (Lecture I.)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section). Messrs. R. L. Smith Rose and R. H. Barfield, "The Effect of Local Conditions on Radio Direction-Finding Installations."

THURSDAY, NOVEMBER 9 .. Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Metals, Institute of, at the Institution of Marine Engineers, 85, Minories, E., 8 p.m. Prof. H. C. H. Carpenter, "The Production of Large Crystals of Aluminium and some of their Properties."

FRIDAY, NOVEMBER 10 .. Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Physical Society, Imperial College of Science, Imperial Institute Road, South Kensington, S.W., 5 p.m.

Timber Trade Lectures, at the London Chamber of Commerce, Oxford Court, Cannon Street, E.C., 6.30 p.m. Mr. H. Stone, "Duhamel, Pioneer in the Study of Wood."

Metals, Institute of (Sheffield Section), The University, Sheffield, 7.30 p.m. Address by the Chairman (Prof. C. H. Desch).

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meeting of the ROYAL SOCIETY OF ARTS, see page 843.

Journal of the Royal Society of Arts.

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FRIDAY, NOVEMBER 10, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2

NOTICES.

NEXT WEEK

MONDAY, NOVEMBER 13th, at 8 p.m. (Special Meeting.) JOHN SLATER, F.R.I.B.A., Member of the Council of the Society, "The Strand and the Adelphi: their Early History and Development." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council and a Vice-President of the Society, will preside. (The paper will be fully illustrated with lantern slides.)

WEDNESDAY, NOVEMBER 15th, at 8 p.m. (Ordinary Meeting.) Overingenieur DR. SIGURD SMITH (Charlottenlund, Denmark), "The Action of the Beater in Paper Making, with special reference to the Theory of the Fibre Board and its application to Old and New Problems of Beater Design." Captain W. E. NUTTALL, M.B.E., Chairman of the Technical Section, Papermakers' Association, will preside. (Lantern illustrations.)

FRIDAY, NOVEMBER 17th., at 4.30 p.m. (Indian Section). J. W. MEARES, C.I.E., M.Inst.C.E., M.I.E.E., Member of the Institution of Engineers (India), "The Development of Water Power in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., F.G.S., Rector of the Imperial College of Science and Technology, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "The Mechanical Design of Scientific Instruments," by Professor Alan F. C Pollard, F.Inst.P.. A.M.I.E.E., have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been reprinted and are still on sale can also be obtained on application.

EXAMINATIONS, 1922.

It is gratifying to note that the popularity of the Society's examinations, which has been established for many years, is steadily increasing. In 1919, the first year after the war, the number of papers worked was 31,132; this figure increased in 1920 to 49,390; in 1921 to 51,267; while this year it again broke all records by rising to 56,775.

The principal reason for this growing popularity is, no doubt, to be found in the ever-increasing number of students who are seriously pursuing courses of study in commercial subjects and modern languages, For these the London County Council and the Local Education Authorities throughout the country are now providing facilities for study on an immense scale. The Society's Examinations furnish them with a valuable stimulus and a definite goal, while the certificates gained by successful candidates offer reliable evidence of the proficiency which they have acquired in their respective subjects. The value of these certificates is becoming every year more and more widely known. A very considerable number of the larger business firms now directly encourage their employees to enter for these Examinations, and many grade their junior staffs according to the successes which they obtain.

With a view to encouraging this movement a circular letter, signed by Lord Askwith, Chairman of the Council, and Sir Philip Magnus, Bt., Chairman of the Examinations Committee, has recently been addressed to a large number of firms throughout the country, urging them to give facilities to their junior employees to attend Evening Classes with a view to furthering their education and to their taking recognised examinations at the end of each session. Many manufacturing and commercial firms in London and the provinces already make valuable concessions of this nature to their staffs, and it is hoped that their example may be more widely followed.

It is often the case that young people on leaving school are by no means eager to pursue their education further, and it is only after a lapse of years that they realise they have lost valuable time in not taking up the study of various commercial subjects not included in the school curriculum. Advice and encouragement in such matters from a principal or manager in the office does much to correct this attitude of mind in the young clerk, and experience shows that such advice often carries more weight than parental influence. Employers can, in this way, do much to raise the efficiency and usefulness of their clerks and thus benefit themselves and the community at large.

It is, of course, true that much of the work in an office is specialised and peculiar to the firm in question, but it is nevertheless the fact that an employee who, in his spare time, acquires a good knowledge of Book-keeping, or Shorthand and Typewriting, or a Modern Language, as well as a theoretica knowledge of the principles of commerce, must be far more useful than one who is satisfied to pick up merely the routine work of the office. A clerk who takes an approved course of study and attends classes regularly at a commercial institute becomes a more valuable and reliable member of the office staff: he improves his memory, gains initiative and takes a more intelligent interest in his work.

With regard to the Examinations of 1922, it will not perhaps be out of place to preface the report with a few words on their conduct in Ireland.

Ireland has for many years provided a fair proportion of the candidates, and it is greatly to her credit that this year the proportion has been well maintained. Especially is this true of Belfast. The conditions there during the period when the May-June Examinations were being held were at their very worst. Extracts from the reports of the Superintendents in Belfast show what had to be faced by the candidates in working their papers. One writes: "Everyone connected with these Examinations deserves a medal for pluck in attending. It was not easy to read Shorthand speed last night to the tune of rifle and machine gun fire. At one instant I thought we should have to give up the attempt to carry on." Another writes: "The dictation at this School was read under very trying conditions. When the reader commenced heavy firing started in a neighbouring street and the effect was evident on the students." And again: "The conditions were worse last night than ever. Some of those going to the School met in Royal Avenue wounded men carried out from the fighting line; and the Superintendents had to pass through such scenes to get to the School." All honour both to the candidates and superintendents who carried on the work in the midst of such difficulties and dangers!

The Examinations were held, as usual, at two periods, March-April and May-June. In March-April the number of entries was 22,160 and in May-June 38,172. The papers worked were divided between the two Examinations as follows:—

	March-April.	May-June.	Total.
Advanced Stage	2,371	6,052	8,423
Intermediate Stage	5,903	14,313	20,216
Elementary Stage	12,699	15,437	28,136

In addition to the 56,775 papers worked in the written examinations, 925 candidates presented themselves for the *viva voce* Examinations in Modern Languages.

The subjects of Examinations this year were:—

Arithmetic.
English.
Book-keeping.
Shorthand.
Typewriting.
Economic Geography.
Economic History.
Economic Theory.
Précis-writing.
Commercial Correspondence and Business Knowledge.
Commercial Law.
Company Law.
Accounting.
Banking.
Theory and Practice of Commerce.
Railway Law and Practice.
Railway Economics.
Shipping Law and Practice.
History of Inland Transport.
Insurance Law and Practice.
French.
German.
Italian.

Spanish.
Russian.
Dutch.
Portuguese.
Swedish.

Arithmetic.—The total number of papers worked in all three Stages was 5,560, as compared with 4,387 in 1921. In Stage III. the number of papers worked was 204: 24 candidates obtained first-class certificates, 82 obtained second-class certificates, and 98 failed. The Examiner reports that while he received a few really excellent papers in this Stage, many candidates entered who were nowhere near the required standard, having, *e.g.*, no understanding of logarithms, nor training in mensuration.

In Stage II. there were 1,282 candidates, of whom 170 obtained first-class certificates, 611 obtained second-class certificates, and 501 failed. The failures were, of course, mainly due to incomplete preparation; but in some cases "howlers" could have been prevented by the exercise of a little intelligence. For instance, one candidate, informed that the population of New Zealand in 1911 was 1,008,468, and that the increase per 1,000 since then was 208, worked out the present population at more than 200,000,000,000!

In Stage I. there were 4,074 candidates, of whom 2,911 passed and 1,163 failed. The Mental Arithmetic is better than in 1921, while the work of Part II. is also satisfactory on the whole. Unfortunately, the Examiner has to complain, as usual, of the very bad style in which candidates from some centres are allowed to do their work. This is, of course, a familiar *cri de cœur* of examiners in every subject. If students and teachers could only realise how much good style counts in presenting an answer in an examination, they would surely devote more attention to this side of their work.

English.—The total number of papers worked in all three Stages was 3,790, as compared with 2,930 last year. The highest previous entry was 3,351 in 1920, when English was one of the subjects set for the special *Daily Sketch* prizes. It is satisfactory to note that the figure for this year is the highest on record, but in view of the importance of English as the bedrock of all our education, commercial or otherwise, one would like to see still further large increases in this subject.

In Stage III. the number of candidates was 213, of whom 14 obtained first-class certificates, 109 obtained second-class certificates, and 90 failed. The corresponding figure for last year was 106, so that there has been an increase of 100 per cent. in this Stage. This in itself is satisfactory, but, unfortunately, there does not appear to have been any improvement in quality proportional to the increase in quantity. In spite of some excellent work the essays and the précis-writing were generally poor. For the first time in this Stage prescribed books were set, and the Examiner reports that as a rule the answers to the questions set on these gave most satisfaction.

In Stage II. there were 1,154 candidates, of whom 99 obtained first-class certificates, 693 obtained second-class certificates, and 362 failed. Here, again, prescribed books were set for the first time. The Examiner reports that, as a rule, the work on "The Idylls of the King" was good, while that on "Gulliver's Travels" was generally weak.

In Stage I. 2,423 papers were worked; 1,594 candidates passed and 829 failed. The Examiner reports some improvement in the analysis of sentences, although in certain centres the work on this question was deplorable. With regard to the essay writing, there seems to be a growing tendency among younger candidates to write irrelevantly and to enlarge upon points which have nothing whatever to do with the main issue. In certain groups the fault is so marked as to suggest that it is not discouraged by the teachers. Some of the answers to the "character" questions brought curious information: according to one writer, "Shylock is a famous detective (surname Holmes) and he appears in 'The Merchant of Venus;'" while another described *Horatius* as "one of Mickawber's most famous poems."

Book-keeping.—This is still far and away the most popular of the subjects of examination. The number of papers worked in all three stages was 18,684, as compared with 17,300 in 1921. The subject coming nearest to it in popularity is Shorthand, in which the number of papers worked this year was 11,229.

In Stage III., 3,565 papers were worked. 410 candidates obtained first-class certificates, 1,804 obtained second-class certificates, and 1,351 failed. Some very good work was submitted in this Stage, but the Examiner draws attention to the fact that many candidates were without useful

knowledge of Cost Accounts—a subject of growing importance to-day.

In Stage II. 6,711 candidates presented themselves, of whom 888 obtained first-class certificates, 4,197 obtained second-class certificates, and 1,626 failed. The quality of the work shows a distinct improvement as compared with that of last year, although, unfortunately, according to the Examiner, "a large number of candidates appear incapable of expressing intelligently in words their knowledge with regard to the questions asked."

In Stage I., of 8,408 candidates, 5,187 passed and 3,221 failed. The attention of teachers should be drawn to the report of the Examiner: "It is noted with regret that a certain number of candidates, when dealing with purchases, sales and kindred items, still employ methods long fallen into disusage, and quite impracticable in modern commerce. Textbooks of authority do not advocate these methods: it can only be assumed, therefore, that some teachers have failed to keep in touch with modern practice."

Shorthand. The total number of papers worked this year was 11,229, an increase of 389 over the figure for 1921. In Stage III. there were 971 candidates, of whom 70 passed the 140 words per minute test, 490 passed the 120 words per minute test, and 411 failed. In Stage II. there were 5,184 candidates, of whom 1,572 passed the 100 words per minute test, 1,846 passed the 80 words per minute test, and 1,766 failed. In Stage I. tests at both 50 and 60 words per minute were introduced this year. 5,074 papers were worked. 2,325 candidates passed the 60 words per minute test; 1,626 passed the 50 words per minute test, and 1,123 failed.

The Examiner in his report quotes a large number of the mistakes made by candidates, which, as he takes care to point out, are by no means restricted to writers of Pitman's Shorthand. Among these may be mentioned "assured all over there are terms" for "shared by every other Railway Chairman"; "numbers and accounts" for "pros and cons"; "to prejudice a shareholder by seeming to turn a blind eye to facts" for "to preach a shallow optimism that turned a blind eye to facts"; "decreased gas in the price" for "prominence given in the press"; "take in February the fact" for "it never can be felt." In Stage I. "York" was turned into "Hull," "Selkirk," "Sligo," "Wigan," and "Warwick"; "our complement of horses" into "our compliments to the horses." Outlines were often guessed at without the slightest consideration of the context. Geographical names and the headings of letters fared badly: thus the words "Stoke-on-Trent. 1st August, 1922," were turned into "Exchanged in transfer, justified in London, 1922," and "Stoke Newington, Distrain, First class, 1922."

Typewriting.—The total number of papers worked was 5,136, as compared with 4,503 in 1921. In Stage III. 507 scripts were submitted: 142 obtained first-class certificates, 235 obtained second-class certificates, and 130 failed. There would appear to be plenty of room for improvement in the methods of displaying the work, and in making effective use of varying line-spacing, width of margins and so forth; while many candidates failed altogether in the Time Test.

In Stage II. the papers worked were 1,767: 526 candidates obtained first-class certificates, 869 obtained second-class certificates, and 372 failed. The work in this Stage was on the whole better than in previous years, and, indeed, was more accurate and better displayed than much of that submitted in Stage III.

In Stage I. 2,862 papers were worked: 1,895 candidates passed, while 967 failed. Here, again, the Examiner complains of the lack of education and general intelligence shown by many of the candidates. Bad mis-spellings indicated unfitness for position as typists: the plural of tableau was given by one candidate as "tabloids;" of "man-of-war" as "sailor;" of "woman-servant" as "domestic servant;" one defined "a perfect erasure" as "a mistake that cannot be rubbed out;" while another wrote "there has been many decades during the past year."

Economic Geography.—285 papers were worked: in Stage III. four candidates obtained first-class certificates, 14 obtained second-class certificates, and 13 failed. Too many candidates are still careless or ignorant about such fundamental points as latitude and longitude, rainfall, the meaning of such terms as "natural region," and so forth. In Stage II. 9 candidates obtained first-class certificates, 63 obtained second-class certificates, and 31 failed. Apparently more attention than usual has been paid to the Examiner's reports with the result that the answers to the

compulsory part of the paper showed considerable improvement; but here again the ignorance as to the meaning of the term "natural region" was very general. The average of the work done was greatly reduced by the presence of a number of candidates who should have entered for the Elementary Stage. In Stage I. 100 candidates passed and 51 failed. Here, as indeed throughout the subject, the Examiner is of opinion that much of the teaching is bad, and is completely divorced from any intelligent study of the physical features. On the other hand there is wide evidence of "cramming" the commercial facts, and this leads to absurd errors which would not be made if the candidates had a glimmering of the reasons of the facts which they so ignorantly mis-state.

Economic History.—The number of papers worked was 53. In Stage III., of 21 candidates none obtained first-class certificates, 15 obtained second-class certificates, and 6 failed. The work was generally satisfactory, although none of striking quality was submitted. In Stage II. one candidate obtained a first-class certificate, 8 obtained second-class certificates, and 23 failed. Unfortunately, as was the case last year, most of the work in this Stage was very poor, and showed little or no real knowledge of history.

Economic Theory.—The number of papers worked was 259. In Stage III. 25 candidates obtained first-class certificates, 63 obtained second-class certificates, and 28 failed. The general character of the work was satisfactory, some of it of high quality, although, as usually happens, the Examination was attempted by a certain number who should have been content to enter in a lower Stage. In Stage II. 15 candidates obtained first-class certificates, 85 obtained second-class certificates, and 43 failed.

Précis-Writing.—The number of papers worked was 114. In Stage III. 25 candidates obtained first-class certificates, 63 obtained second-class certificates, and 28 failed. The worst fault was prolixity, and it was evident that many candidates had not practised the art of restricting themselves within a set limit of words. In some cases they exceeded the prescribed number, 300, by 500 words or more. The work in Stage II. (where 8 obtained first-class certificates, 37 obtained second-class certificates, and 11 failed) was decidedly better in this respect, and candidates generally showed some power of epitomising the subject matter.

Commercial Correspondence and Business Knowledge.—The total number of papers worked was 3,935. In Stage III. 4 candidates obtained first-class certificates, 38 obtained second-class certificates, and 48 failed. In Stage II. 55 obtained first-class certificates, 762 obtained second-class certificates, and 306 failed. In Stage I. 1,796 passed and 926 failed. Almost all candidates were very weak in Commercial Correspondence. "It should be clearly realised," writes the Examiner, "that ability to express oneself clearly, in a manner calculated to convey the desired impression and leave no room for doubt, is an essential condition for success in this Examination."

Commercial Law. — 520 papers were worked. In Stage III. 29 candidates obtained first-class certificates, 217 obtained second-class certificates, and 61 failed. But for the fact that a number of candidates took this Stage who should have entered for Stage II., the work here would have been extremely satisfactory. As the Examiner remarks in his report, no candidate should attempt this Examination unless he has studied the subject for at least two years or has previously obtained a pass in Stage II. Complaint is also made here, as indeed by most Examiners, of bad spelling, bad writing, bad composition and bad arrangement of the answers—faults which ought not to exist at this Stage. In Stage II. 49 obtained first-class certificates, 133 obtained second-class certificates, and 31 failed. While these figures indicate a good average of work, various extracts quoted from the answers in the Examiner's report show that he has only too much reason to complain of illiteracy on the part of various candidates.

Company Law.—344 papers were worked. In Stage III. 18 candidates obtained first-class certificates, 120 obtained second-class certificates, and 35 failed. The majority of the papers were carefully and intelligently written, and showed that the writers possessed a sound knowledge of the principles of the subject. In Stage II. 49 candidates obtained first-class certificates, 112 obtained second-class certificates, and only 10 failed. Here again it was clear that the great majority had a sound knowledge of the elementary principles of Company Law, though a good many showed an imperfect

acquaintance wtith the form and substance of a Memorandum of Association.

Accounting.—745 candidates sat for this examination, of whom 95 obtained first-class certificates, 386 obtained second-class certificates, and 264 failed. The work sent in was creditable, but a good many candidates showed weakness in answering Income Tax Questions.

Banking.—The number of papers worked was 66. Ten candidates obtained first-class certificates, 26 obtained second-class certificates, and 30 failed.

Theory and Practice of Commerce.—For the first time an Examination in Stage I. of this subject was introduced this year. The total number of papers worked in all three Stages was 570. In Stage III. 16 candidates obtained first-class certificates, 101 obtained second-class certificates, and 59 failed. In Stage II. 24 obtained first-class certificates, 205 obtained second-class certificates, and 83 failed. In Stage I. 16 passed, while 66 failed. The large percentage of failures in the last-named Stage is very noticeable: as the Syllabus covers a very limited field candidates are expected to show a reasonable knowledge of the subjects set. In all three Stages the Examiner thinks that better results would be obtained if teachers gave their students more frequent opportunities of expressing their ideas in writing.

Railway Law and Practice. 207 papers were worked in this subject. 50 candidates obtained first-class certificates, 110 obtained second-class certificates, and 47 failed. Here again the Examiner complains of the defective general education of many of the students, some of whom, he says, "ought to go back and take a course in English."

Railway Economics. — This subject was introduced into the Syllabus this year. 67 candidates presented themselves, of whom 15 obtained first-class certificates, 28 obtained second-class certificates, and 24 failed. Taken on the whole, the examinees were well prepared.

Shipping Law and Practice.—Only 22 candidates entered for this subject an unsatisfactory figure when the enormous size and importance of the shipping industry of this country is borne in mind. Five candidates obtained first-class certificates, 10 obtained second-class certificates, and 7 failed. Again the Examiner complains of the very poor standard of general education possessed by the Candidates. "The spelling was lamentably weak, and this often went with a very limited power of expression. In fact, many of the candidates are sadly lacking in their knowledge of their mother-tongue. This was fatal to their rendering first-class answers to the questions set." It is deplorable that it should be necessary to write in this way of candidates in Stage III.

The History of Inland Transport, a new subject of examination this year, only attracted one Candidate, who was awarded a second-class certificate.

Insurance Law and Practice, also introduced this year, only attracted two candidates, of whom one obtained a second-class certificate, and the other failed.

MODERN LANGUAGES.

French.—The total number of papers worked in this subject was 4,070, as compared with 3,697 in 1921. In Stage III. 67 candidates obtained first-class certificates, 326 obtained second-class certificates, and 256 failed. It is satisfactory to learn that "some quite delightful essays were written on the subject 'Les Chateaux en Espagne,'" but, on the other hand, a good many candidates exhibited an ignorance of grammar which is quite inexcusable in an advanced examination. In Stage II. 139 candidates obtained first-class certificates, 876 obtained second-class certificates, and 553 failed. Whilst a certain number of very good papers were worked, the Examiner reports again in many of the weaker students an ignorance of grammar which is almost staggering. Such forms as *je faisait, je marcha, vous connais* occurred in about fifty per cent. of the papers. It is to be feared that there is a very strong tendency to slipshod teaching which, while attempting to build up a showy superstructure leaves the foundations to take care of themselves. A thorough grasp of grammar is and must always remain the bedrock on which to raise a knowledge of any language, and teachers who imagine that they can dispense with this are laying up trouble for themselves and for their luckless pupils.

In Stage I. 1,309 candidates passed and 544 failed. The results here appear to have been generally satisfactory.

German still shows but little sign of recovering its pre-war popularity, when the number of papers worked was 826 (in 1914). Indeed, the figure this year, 276, shows a

falling off of 56 as compared with that of 1921. In Stage III. 12 candidates obtained first-class certificates, 36 obtained second-class certificates, and 8 failed. The work here was rather below the usual standard. In Stage II. 21 candidates obtained first-class certificates, 55 obtained second-class certificates, and 28 failed. While several of the papers were excellent, the general level was not high: there was much weakness in grammar, and much slipshod and untidy writing, both in English and German. In Stage I. 59 candidates passed and 57 failed. Here, unfortunately, the standard of work was (except in a few cases) very low. The failures, which were far too numerous, were due to gross carelessness and ignorance of grammar.

Italian.—In Stage III., of 20 candidates, 8 obtained first-class certificates, 7 obtained second-class certificates, and 5 failed. In Stage II. 9 obtained first-class certificates, 21 obtained second-class certificates, and one failed. In Stage I. 39 passed and 3 failed. The small proportion of failures in all Stages is satisfactory.

Spanish.—The number of entries in Spanish continues to increase steadily. This year 676 papers were worked, as compared with 633 in 1921. In Stage III. there were 131 candidates, of whom 17 obtained first-class certificates, 72 obtained second-class certificates, and 42 failed. Here, again, complaints are made of the students' ignorance of the grammar, but, on the other hand, the essays were, as a rule, satisfactory. In Stage II. 26 candidates obtained first-class certificates, 150 obtained second-class certificates, and 55 failed. The Examiner reports favourably on the general excellence of the work in this Stage, which shows a distinct improvement over that done in previous years. In Stage I. 264 candidates passed and 50 failed. The work on the whole was satisfactory, although there was room for considerable improvement in the knowledge of grammatical rules.

Russian.—In 1917, when high hopes were entertained of the assistance which Russia was going to give the Allies in the War, a remarkable impulse was given to the study of Russian in this country. As one result of this the number of entries at the Society's Examinations rose to 266. With the collapse of the Russian Empire this number fell rapidly, and this year the total number of papers worked was only 43. In Stage III. 4 candidates obtained first-class certificates, 7 obtained second-class certificates, and 2 failed. The average quality of the work was rather poor, and students should realise that it is useless to attempt the examination in this Stage unless they possess a thorough knowledge of Russian grammar, idiom, and advanced syntax. In Stage II. 5 candidates obtained first-class certificates, 10 obtained second-class certificates, and—a most satisfactory feature—there were no failures. In Stage I. 12 candidates passed and 3 failed. The work here reached a higher standard than last year, and there was a distinct improvement in the answers to the grammatical questions.

Dutch.—Only 7 papers were worked in this subject. In Stage III. one candidate obtained a second-class certificate and one failed. In Stage II. 2 candidates obtained second-class certificates and 3 failed. The work was of very poor quality in both Stages. The Examiner mentions that all candidates in Dutch seem to assume that the German and Dutch languages are practically identical, and that if they obtain a certificate in German, their success in Dutch will follow as a matter of course with very little additional study. This is a grave error.

Portuguese.—The number of papers worked in this subject was 13, the same number as last year. In Stage III. one candidate obtained a first-class certificate, 6 obtained second-class certificates, and one failed. In Stage II. one obtained a first-class certificate, 3 obtained second-class certificates, and one failed.

Swedish.—In Stage III. one candidate obtained a first-class certificate, one obtained a second-class certificate, and one failed. In Stage II. the results were very poor: one candidate obtained a first-class certificate and four failed.

Commercial Knowledge Certificates.

The increase, noted in last year's report, in the number of Candidates entered from Higher Elementary Schools, and also the new Central Day Schools set up under various Education Authorities, has been well maintained. Most of these Candidates take a group of subjects qualifying for the Certificate in Elementary Commercial Knowledge. To gain this special Certificate, Candidates must pass in Arithmetic, Book-keeping, English and one other subject within three consecutive years, but it is

satisfactory to find that many pupils from the Day Schools mentioned above, pass in the necessary subjects in one year. In view of the fact that a fairly high standard is maintained in the Elementary Stage (it is by no means a first year's examination) the results at Day Schools under the local Education Authorities mentioned, set forth in the following table give evidence of really excellent preparation.

	Elementary Stage, 1922.		
	Number of Candidates.	Number of Papers Worked.	Number of Certificates Awarded.
(*a*) April Examinations :—			
Chatham, Junior Commercial School	42	115	97
Kingston-on-Thames, Day Commercial School.. ..	78	158	143
Leyton, Capworth Street School..	99	272	213
Leyton, Norlington Road School..	35	78	65
West Ham, Central Secondary School	28	84	77
L.C.C. Brockley Central School	62	90	82
L.C.C. Brownhill Road Central School	29	56	53
L.C.C. Charlton Central School	37	120	110
(*b*) May Examinations :—			
Cheltenham Central School	48	54	51
Colchester, Hamilton Road Central School	38	51	47
Croydon, "John Ruskin" Central School	131	230	195
Derby, Central Girls' School	23	72	60
East Ham, "Wakefield" Central School	193	570	408
Halifax, Municipal Technical College	143	236	218
Lerwick, Central Public School	11	36	35
Northampton, Town and County School..	30	93	80
West Ham, Water Lane Higher Elementary School ..	26	164	146
Wood Green, Central County School	34	84	80
London, "Mary Datchelor" Girls' School	18	40	40

a candidate is that he should be able to express himself correctly in his mother-tongue. The advice, which is obvious enough, ought to be quite unnecessary: unfortunately, it is not.

The second point is akin to the first. From all the Examiners in Modern Languages comes the same complaint: candidates do not know the grammar of the languages which they are supposed to have studied. To master the grammar of a language undoubtedly entails long hours of hard, uncompromising work; and it is to be feared there are many, both among teachers and students, who shirk what they can only make a dull and uninteresting task, and are content with a superficial and inaccurate acquaintance with a more or less extensive vocabulary. Such an acquaintance is of little or no value. No one has any really adequate knowledge of a language unless he is firmly grounded in the main principles of its grammar. This remark again is obvious and ought to be unnecessary. Again, unfortunately, it is not.

After a careful study of the Examiners' Reports, two principal facts emerge. Bitter complaint is made by nearly all the Examiners that in many cases the candidates' ignorance of their mother tongue is profound. A very large number of the failures in all subjects and in all Stages is due to this cause. Both teachers and students ought to realise that high marks cannot be given to a candidate whose [illegible]elling and grammar are very defective, [illegible] cannot be too strongly impressed [illegible] who have to do with the training [illegible]ailed. As [illegible] for these, or, indeed for any, [illegible] of the very [illegible] that the first essential in

DETAILS OF THE 1922 EXAMINATIONS.

Subjects.	Stage III.—Advanced.				Stage II.—Intermediate.				Stage I.—Elementary.			Total number of Papers worked in all Stages.	
	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	Passed.	Not passed.	1922	1921
Arithmetic	204	24	82	98	1,282	170	611	501	4,074	2,911	1,163	5,560	4,387
English	213	14	109	90	1,154	99	693	362	2,423	1,594	829	3,790	2,930
Book-keeping	3,565	410	1,804	1,351	6,711	888	4,197	1,626	8,408	5,187	3,221	18,684	17,300
Economic Geography	31	4	14	13	103	9	63	31	151	100	51	285	227
Shorthand	971	79	490	411	5,184	1,572	1,846	1,766	5,074	3,951	1,123	11,229	10,840
Typewriting	507	142	235	130	1,767	526	869	372	2,862	1,895	967	5,136	4,503
Economic History	21	—	15	6	32	1	8	23	—	—	—	53	87
Economic Theory	116	25	63	28	143	15	85	43	—	—	—	259	264
Précis-writing	58	4	36	18	56	8	37	11	—	—	—	114	110
Commercial Correspondence and Business Knowledge ...	90	4	38	48	1,123	55	762	306	2,722	1,796	926	3,935	3,219
Commerical Law	307	29	217	61	213	49	133	31	—	—	—	520	545
Company Law	173	18	120	35	171	49	112	10	—	—	—	344	433
Accounting	745	95	386	264	—	—	—	—	—	—	—	745	804
Banking	66	10	26	30	—	—	—	—	—	—	—	66	59
Theory and Practice of Commerce	176	16	101	59	312	25	205	83	82	16	66	570	555
Railway Law and Practice ...	207	50	110	47	—	—	—	—	—	—	—	207	157
Railway Economics	67	15	28	24	—	—	—	—	—	—	—	67	—
Shipping Law and Practice ...	22	5	10	7	—	—	—	—	—	—	—	22	23
History of Inland Transport...	—	—	—	—	1	—	1	—	—	—	—	1	—
Insurance Law and Practice ...	2	—	1	1	—	—	—	—	—	—	—	2	—
French	649	67	326	256	1,568	139	876	553	1,853	1,309	544	4,070	3,697
German	56	12	36	8	104	21	55	28	116	59	57	276	332
Italian	20	8	7	5	31	9	21	1	42	39	3	93	79
Spanish	131	17	72	42	231	26	150	55	314	264	50	676	633
Russian	13	4	7	2	15	5	10	—	15	12	3	43	55
Dutch	2	—	1	1	5	—	2	3	—	—	—	7	8
Portuguese	8	1	6	1	5	1	3	1	—	—	—	13	13
Swedish	3	1	1	1	5	1	—	4	—	—	—	8	7
Totals, 1922	8,423	1,045	4,341	3,037	20,216	3,667	10,739	5,810	28,136	19,133	9,003	56,775	—
" 1921	8,125	1,141	4,183	2,801	19,093	2,756	10,216	6,121	24,049	15,994	8,055	—	51,267

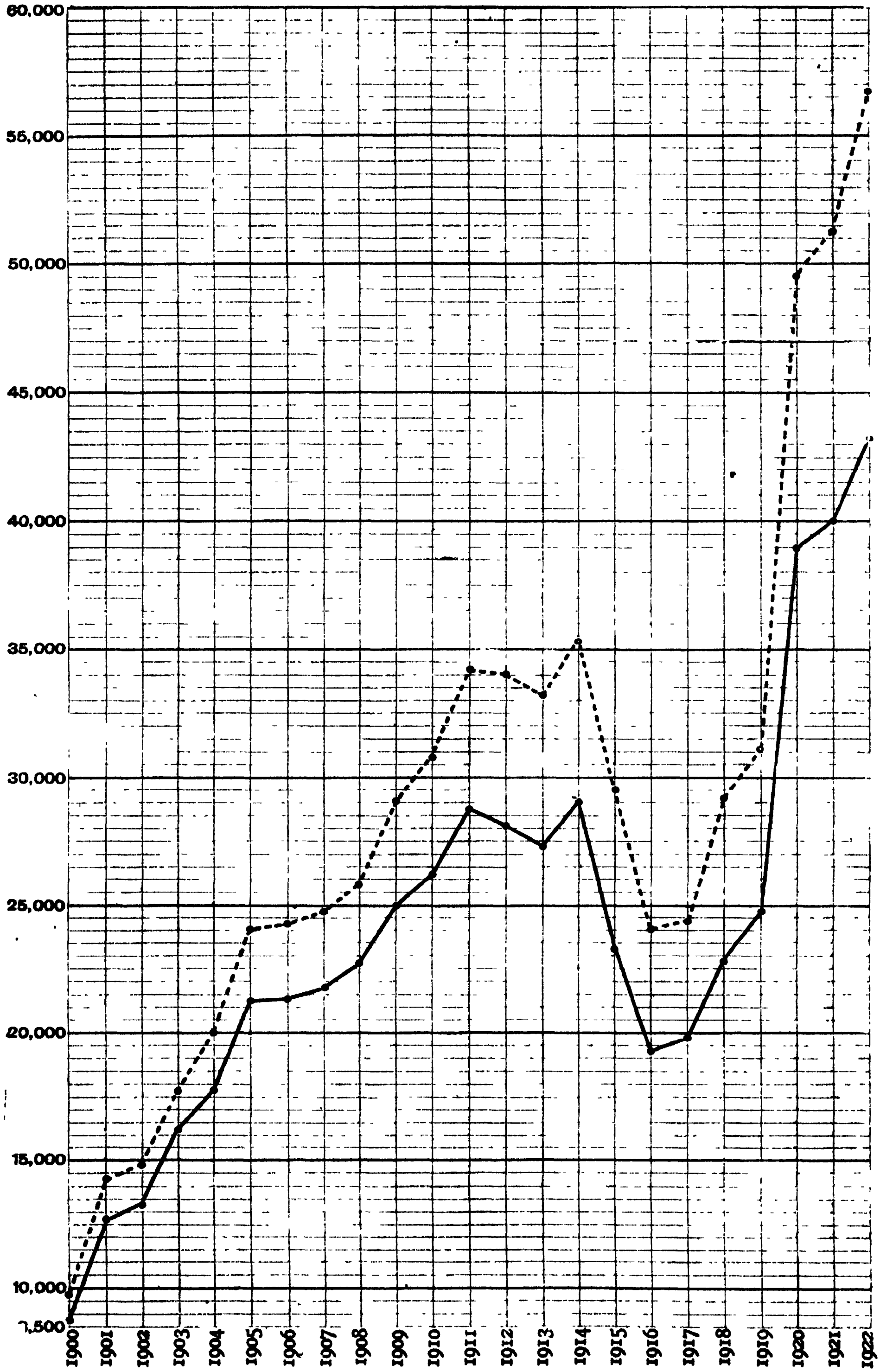

DIAGRAM SHOWING PROGRESS OF EXAMINATIONS, 1900-1922.

The continuous line shows the number of candidates, the dotted line the number of papers worked.

The thanks of the Council are again accorded to the Court of the Clothworkers' Company, who have generously renewed their grant of £40, to be expended in providing medals in all the subjects of examination where the work of candidates attains a sufficiently high standard. There is no doubt that these medals are highly valued by those who win them, and they have done much to maintain or raise the level of excellence in the papers worked.

The Examination Syllabus for 1923* has been issued. In it will be found the fullest possible information about the examinations, a syllabus of each stage of each subject, and a list of centres. The papers set in April and May, 1922, have been reprinted in six pamphlets. Each pamphlet contains, in addition to the papers of each stage, the syllabuses of the subjects in the pamphlet and the Examiners' reports on the papers worked. The attention of both teachers and students may be drawn once more not only to the syllabuses, but also to the remarks of the various examiners on the results of last year. It will be found that these contain many valuable and helpful suggestions, and the work of the candidates year after year shows that far too little attention is paid to them.

The regulations for the Oral Examinations in Modern Languages are also given at full length in the syllabus.

* The price of the Syllabus for 1923 is 4*d*., post free. Copies can be obtained on application to the Examinations Officer, Royal Society of Arts, Adelphi, London, W.C. (2). The price of the pamphlets containing the 1922 papers is 4*d*. each, post free. Particulars of these may be obtained as above.

ORAL EXAMINATIONS HELD DURING 1922.

Subject.	No. of Examination Centres.	No. of Examiners	No. of Candidates examined.	Passed with Distinction.	Passed.	Failed.
French	52	35	717	83	427	207
German	9	8	57	16	36	5
Spanish	14	11	125	36	72	17
Italian	4	4	20	5	12	3
Russian	1	1	6	2	4	—
	80	58	925	142	551	232

NOTES ON BOOKS.

BUSINESS GEOGRAPHY. By Ellsworth Hungtington and Frank E. Williams, with the co-operation of Robert M. Brown and Lenox E. Chase. New York: John Wiley and Sons, Inc., London: Chapman and Hall, Ltd. 13*s*. 6*d*. net.

Probably in no class of text books has there been more improvement during the last quarter of a century than in those which deal with geography, and some of the best of these come from America. A little while ago the writer of this note met a young Oxford geographer who was forsaking Isis for the Hudson River "because they take geography seriously in the States." This book, which is one of a series by Mr. Elsworth Hungtington, in collaboration with other writers, goes far to prove that the Oxonian was right. The modern conception of geography—at all events in America, though we hope not only there—is immense: it embraces not merely physical and political features, but practically every aspect of human activity.

The present volume treats of the kind of geography that the business man needs. It deals in the first instance with principles, and the effects of specific geographic factors; it then passes on to types of business communities, the business of the continents, and the business of the United States. A student who has mastered the book will have a very good general knowledge of the various industries carried on in different parts of the world, and he will know why they have grown up in such and such parts rather than elsewhere. Nothing connected with human activity is alien to the modern geographer; thus, we have illustrations of Mexicans baking bread in a primitive mud oven, and of an Indian coolie lying on his back and working a punkah with his foot, and also particulars of the great "movie" industry in

connection with which it is estimated that the picture theatres take well over a billion, and perhaps nearly a billion and a half dollars, a year.

An excellent feature of the book is the problems set at the end of each chapter, which should start the student thinking for himself There are also a large number of tables specially calculated to give material for map making

THE LIBRARY.

The following books have been presented to the Library since the last announcement. Except where otherwise stated, they have been presented by the publishers:—

Anglo-Mexican Petroleum Co, Ltd. Mex Fuel Oil. Second Edition. London: George Philip & Son, Ltd., 1921.

Beck, Ernest G. Real Mathematics London: Henry Frowde & Hodder & Stoughton 1922.

Beilby, Sir George, F.R.S.—Aggregation & Flow of Solids. London: Macmillan & Co, Ltd. 1921.

Birck, Dr. L. V.—The Theory of Marginal Value. London: George Routledge & Sons, Ltd. 1922.

Bisacre, F. F. P., O B.E., M.A., B.Sc—Applied Calculus. London: Blackie & Son, Ltd. 1921.

Cain, John Cannell, D.Sc.—The Manufacture of Dyes. London: Macmillan & Co., Ltd 1922.

Chittick, James.—Silk Manufacturing and its Problems. New York 1913. Presented by the Author.

Clapham, Charles B., B.Sc—Metric System for Engineers. London: Chapman & Hall, Ltd. 1921.

Cornford, L. Cope.—The Designers of our Buildings. London: Royal Institute of British Architects. 1921.

Cross, Charles F. and Charles Dorée.—Researches on Cellulose (1910-1921). London: Longmans Green & Co. 1922.

Cundall, Frank, F.S.A.—Handbook of Jamaica, 1922. London: Edward Stanford. 1922.

Dawson, Robert MacGregor, M.A., D.Sc.—The Principle of Official Independence. London: P. S. King and Son, Ltd. 1922.

Deerr, Noël.—Cane Sugar. Second Edition. London: Norman Rodger, 1921.

Dudgeon, Gerald C., C.B.E.—The Agricultural & Forest Products of British West Africa. Second Edition. London: John Murray. 1922.

Evans, Edwin J.—Building Contracts. London: Chapman & Hall, Ltd. 1922.

Fleming, A. P. M., C.B.E., M.Sc., and J. G. Pearce, B.Sc.—Research in Industry. London: Sir Isaac Pitman & Sons, Ltd. 1922.

Grasser, Dr. Georg.—Synthetic Tannins. Translated by F. G. A. Enna. London: Crosby Lockwood & Son. 1922.

Gregory, T. E. G., B.Sc.—Tariffs: A Study in Method. London: Charles Griffin & Co, Ltd. 1921.

Hadfield, Sir Robert A., Bt., D.Sc., F.R.S.—The Work and Position of the Metallurgical Chemist. 1921.

Hall, B. J—Blue Printing and Modern Plan Copying. London: Sir Isaac Pitman & Sons, Ltd. 1921.

Hewett, Arthur J—The Letter Cutter's Manual. London: The Trade Papers' Publishing Co, Ltd 1921

Hull, Thomas—Oils, Fats and Fuels London: Blackie & Son, Ltd 1921

Isaac, Charles Percival—The Menace of Money Power London: Jonathan Cape. 1921 Presented by Mr A Honeysett.

Jeans, Herbert The Periods in Interior Decoration London: The Trade Papers' Publishing Co, Ltd 1921.

Kaye, G W C, O.B E., M.A, D Sc The Practical Applications of X-Rays London: Chapman & Hall, Ltd 1922

Lethaby, W. R—Form in Civilization London: Oxford University Press 1922

Loring, F H—Atomic Theories London: Methuen & Co, Ltd 1921

Macara, Sir Charles W, Bt—Recollections London: Cassell & Co., Ltd. 1921

Malinowski, Bronislaw, D.Sc, Ph.D.—Argonauts of the Western Pacific. London: George Routledge and Sons, Ltd. 1922

Matthis, Alfred R.—Insulating Varnishes in Electrotechnics Manchester: John Heywood, Ltd. 1922. Presented by Messrs. Attwater & Sons Preston.

Millar, Andrew.—Painting troubles and their Remedy London: The Trade Publishing Co, Ltd. 1921

Mitzakis, Marcel.—The Oil Encyclopedia. London: Chapman & Hall, Ltd 1922.

Palmer A. Risdon, B Sc, B.A.—Finance Two vols. London: G. Bell & Sons, Ltd 1922

Parr, G. D Aspinall, M.Sc.—Electrical Engineering Testing Fourth Edition London: Chapman & Hall, Ltd 1922.

Pennell, Joseph.—The Graphic Arts. Chicago: University Press

Penzer, N. M., M.A.—The Mineral Resources of Burma. London: George Routledge & Sons, Ltd. 1922.

Redwood, Sir Boverton, Bart, D.Sc.—A Treatise on Petroleum. Fourth Edition. Three Vols. London: Charles Griffin & Co., Ltd. 1922.

Rowntree, H. Seebohm.—The Human Factor in Business. London: Longmans, Green & Co. 1921.

Russell, Edward J., D.Sc., F.R.S. Soil Conditions and Plant Growth. Fourth Edition. London: Longmans, Green & Co. 1921.

Schlich, Sir William, K.C.I.E., F.R.S.—Schlich's Manual of Forestry. Vol. 1. Fourth Edition. London: Bradbury, Agnew & Co., Ltd. 1922.

Stevens, Alexander, M.A., B.Sc. — Applied Geography. London: Blackie & Son, Ltd. 1921.

Verstone, P. E.—The Manufacture of Paper Containers. London: Verstone & Co. 1922.

Woodhouse, Thomas.—1. The Handicraft Art of Weaving. 2. Yarn Counts and Calculations. London: Henry Frowde & Hodder & Stoughton. 1921.

Young, Sydney, M.A., D.Sc., F.R.S.—Distillation Principles and Processes. London: Macmillan & Co., Ltd. 1922.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock (unless otherwise announced):—

November 13 (Monday).—John Slater, F.R.I.B.A., Member of the Council of the Society, "The Strand and the Adelphi: their Early History and Development." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council and a Vice-President of the Society, will preside. (The Paper will be fully illustrated with lantern slides.)

November 15. — Overingenieur Dr. Sigurd Smith (Charlottenlund, Denmark), "The Action of the Beater in Paper Making, with special reference to the Theory of the Fibre Board and its application to Old and New Problems of Beater Design." Captain W. E. Nuttall, M.B.E., Chairman of the Technical Section, Papermakers' Association, will preside. (Lantern illustrations.)

November 22.—Bailie William Smith (Glasgow), Member of the Departmental Committee on Smoke Abatement, "The Economy of Smoke Abatement." The Right Hon. Lord Newton will preside.

November 29.—Major W. S. Tucker, R.E., D.Sc., "The Hot Wire Microphone and its Applications." Admiral of the Fleet Sir Henry B. Jackson, G.C.B., K.C.V.O., D.Sc., F.R.S., will preside.

December 6.—H. Emory Chubb, "Recent Developments in the Manufacture of Safes and Strong Rooms." (With Cinematograph illustrations.) Laurence Currie will preside.

December 13.—Sir Sidney F. Harmer, K.B.E., Sc.D., F.R.S., Director of the British Museum of Natural History, "The Fading of Museum Specimens." The Earl of Crawford and Balcarres, K.T., P.C., F.S.A., will preside.

Indian Section.

Friday afternoons, at 4.30 o'clock.

November 17.—J. W. Meares, C.I.E., M.Inst.C.E., M.I.E.E., Member of the Institution of Engineers (India), "The Development of Water Power in India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector of the Imperial College of Science and Technology, will preside.

December 15.—Commissioner F. de L. Booth Tucker, "The Settlements of Criminal Tribes in India." Sir Edward R. Henry, Bt., G.C.V.O., K.C.B., Inspector-General of Police, Bengal, 1891: Commissioner of Police in the Metropolis, 1903-18, will preside.

Dominions and Colonies Section.

Tuesday afternoon, at 4.30 o'clock.

December 5.—Major Owen Rutter, F.R.G.S., F.R.A.I., "North Borneo" (with Cinematograph Views).

Papers to be Read after Christmas.

Thomas H. Fairbrother, M.Sc., F.I.C., and Arnold Renshaw, M.D., D.P.H., "The relation between Chemical Constitution and Antiseptic Action in the Coal Tar Dyes."

Charles R. Darling, A.R.C.Sc.I., "Electrical Resistance Furnaces and their Uses."

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, South Kensington, "Recent Developments in Surface Combustion."

W. J. Rees, Lecturer on Refractories in the University of Sheffield, "Progress in the Manufacture of Refractories."

Arthur W. Reeves, M.I.Mech.E., M.Inst. Auto. Eng., "Motor Railway Coaches."

Maurice Drake, "The Development of Mediæval Technique in Stained Glass Windows."

Edward Parnell, "The Resources and Trade of Sarawak."

C. Ainsworth Mitchell, M.A., F.I.C., "Handwriting and its value as Evidence."

Professor W. E. S. Turner, D.Sc., Head of Department of Glass Technology, The University, Sheffield, "Heat Resisting Glasses."

The Earl of Ronaldshay, G.C.I.E., late Governor of Bengal, "A Clash of Ideals as a Cause of Indian Unrest."

J. T. MARTEN, I.C. ., M.A., Imperial Census Commissioner in ndia, "The Indian Census, 1921."

SIR RICHARD A. S. REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., F.G.S., The Base Metal Resources of the British Empire."

L. GUY RADCLIFFE, M.Sc. (Tech.), F.I.C., "The Essential Oils of the British Empire."

BRIGADIER - GENERAL H. A. YOUNG, C.I.E., C.B.E., "The Indian Ordnance Factories."

R. W. CHURCH, B.Sc., F.G.S., "Electrification of Indian Coalfields."

LIEUT.-COLONEL SIR LEONARD ROGERS, C.I.E., F.R.S., F.R.C.P., F.R.C.S., Physician and Lecturer, London School of Tropical Medicine, "Recent Advances towards the Solution of the Leprosy Problem."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

January 10, February 16, March 16 April 20, May 11.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock February 6, March 6, May 1.

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor o Chemical Technology, Imperial College of Science and Technology, South Kensington, "Brown Coal and Lignites." Three Lectures. November 27, December 4 and 11.

HENRY P. STEVENS, M.A., Ph.D., F.I.C., "The Vulcanisation of Rubber." Three Lectures. February , 12, 19.

J. E. SEARS, C.B.E., M.A., M.I.Mech.E., Superintendent of Metrology, National Physical Laboratory, and Deputy Warden of the Standards, "Length Measurement." Three Lectures. March 5, 12, 19.

SAMUEL A. DAVIES, Chemical Department, Messrs. Rowntree & Co., York, "Cocoa and Chocolate." Three lectures. April 9, 16, 23.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 13.. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Commander Frank Wild, "The Work of the 'Quest.'"
Surveyor's Institution, 12, Great George Street, S.W., 8 p.m. Address by the President, Mr. J. M. Clark.

TUESDAY, NOVEMBER 14.. Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Reports on progress during the vacation and Developments in Lamps and Lighting appliances
Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. A. Millar, "The Galician-Canadian Pole Tool Drilling System."
Oriental Studies, School of, Finsbury Circus, E.C. Dr. T. G. Bailey, "The Sancis or Thieves of India: their Languages, History and Customs."
Metals Institute of (Scottish Section), 38, Elmbank Crescent, Glasgow, 7.30. Mr. J. W. Donaldson, "Non-Ferrous Alloys and their Uses in Marine Engineering and Shipbuilding."
Chadwick Public Lectures, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 5.15 p.m. Miss A. D. Muncaster, "Some Hygienic Aspects of Food and Food Preparation."

WEDNESDAY, NOVEMBER 15.. University of London, South Kensington, S.W., 5 p.m. Sir Frederick Bridge, "Some Operatic Studies." Lecture I. "Euridice," by Peri (the first Opera, 1600).
Microscopical Society, 20, Hanover Square. W. 1. Mr. C. Beck, "Glare and Flooding in Microscope Illumination." 2. Dr. C. Singer. "The First Mechanical Microtome." 3. Prof. G. S. Thapar, "The Occurrence and Significance of a Third Contractile Vacuole in *Paramecium caudatum*." 4. Prof. B. L. Bhatia, "On the Significance of Extra Contractile Vacuoles in *Paramecium caudatum*."
Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Sir Arthur R. Holbrook, "Industrial Liberty."
Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. G. E. C. Pritchard, "The Scientific Principles underlying Infant Feeding."
University of London, University College, W.C. 6.15 p.m. Mr. A. W. Flux, "Foreign Exchanges - the Relation of Prices in different Countries. Facts and Theories. (Lecture II.)

THURSDAY, NOVEMBER 16. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. R. M. Wood, "The Co-relation of Model and Full Scale Work."
Royal Society, Burlington House, Piccadilly, W., 4 p.m.
Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. A. D'Arcy Chapman, "The Measurement of the Intelligence of School Children in Massachusetts, U.S.A."
British Decorators, Incorporated Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. T. P. Bennett, "Wood-Work."
Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Prof. J. Drinkwater, "Some Contemporary Poets."
Mechanical Engineers, Institution of (Midland Branch), The University, Edmund Street, Birmingham, 7.30 p.m. Mr. J. Fearn, "The Economics of Plant Purchase." (North-Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m. Mr. H. Wilkinson, "Cotton Opening, Mixing and Carding Machinery."
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Prof. M. Walker, "The Improvement of Power Factors" by the late Dr. G. Kapp.
Camera Club, 17, John Street, Adelphi, W.C., 8.15 p.m. Mr. T. H. B. Sharp, "Lourdes."
Linnean Society, Burlington House, Piccadilly, W., 5 p.m.
Chemical Society, Burlington House, Piccadilly, W., 8 p.m.

FRIDAY, NOVEMBER 17. University of London, Zoological Theatre, University College, W.C., 5.15 p.m. Mr. C. T. Regan, "Problems of Evolution, with special reference to Fishes." (Lecture II.)
Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Adjourned Discussion on "Electric Locomotives," by Sir Vincent L. Raven."

Journal of the Royal Society of Arts.

No. 3,652. VOL. LXX.

FRIDAY, NOVEMBER 17, 1922.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FUND FOR PURCHASING AND RENOVATING THE SOCIETY'S HOUSE.

SIXTH LIST.*

	£	s.	d.
Amount previously acknowledged	42,573	15	4
The South Metropolitan Gas Company	105	0	0
The Skinners' Company ..	26	5	0
The late Sir Richard Vassar-Smith, Bt., D.L. ..	21	0	0
Alexander Bremner, Esq. ..	20	0	0
Nathaniel Geach Burch, Esq.	10	10	0
Henry A. Haviland, Esq., M.B.	10	10	0
Sir R. N. Mookerjee, K.C.I.E.	10	0	0
Capt. James Charles Richards	10	0	0
K. Sumitomo, Esq. ..	10	0	0
John Hughes, Esq.	5	5	0
Louis Benjamin Tait, Esq. ..	5	5	0
Colonel Herbert A. Foster ..	5	0	0
Lieut.-Colonel Christian B. Hunter	5	0	0
J. Henry Monk, Esq. ..	5	0	0
George Harvey Whymark, Esq.	3	3	0
John Francis Costello, Esq.	2	2	0
Colonel Nicholas T. Belaiew, C.B.	1	1	0
George Halford, Esq., A.R.C.A.	1	1	0
James Robert Kirk, Esq., M.B.E.	1	1	0
	£42,830	18	4

The above list includes all subscriptions received up to November 14th. Further lists will be published in the *Journal* from time to time.

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will cover the cost of renovating and decorating the House.

* The five former lists were published in the *Journals* of December 2nd, 1921, January 13th, February 24th, May 5th and July 14th, 1922.

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER 22nd, at 8 p.m. (Ordinary Meeting.) BAILIE WILLIAM SMITH (Glasgow), Member of the Departmental Committee on Smoke Abatement, "The Economy of Smoke Abatement." THE RIGHT HON. LORD NEWTON, P.C., D.L., will preside.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 8th, 1922; LORD ASKWITH, K.C.B., D.C.L., K.C., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Allbright, William James, London.
Allan, James Boyd, Motherwell.
Ashford, Colonel Bailey K., M D., D.Sc., C.M.G., San Juan, Porto Rico.
Atal, Brijmohan Lal, F.C.I., Chaura Rasta, Jaipur State, Rajputana, India.
Bailey, Thaddeus F., Alliance, Ohio, U.S.A.
Baker, Webster E. Byron, York, Penna., U.S.A.
Barton, P. A., Bangalore, India.
Bhargava, Rai Sahib Trilok Nath, B.A., Lucknow, India.
Bull, Alec G., Sutton, Surrey.
Cann, Edmund Henry Hope, Salkhia, India.
Cantell, Mark Taylor, M.Am.Soc.M.E., Winnipeg, Manitoba, Canada.
Chand, Hari, A.M.I.E.E., Sitapur, U.P., India.
Chatterjee, Nirmal Chandra, Dibrugarh, Assam, India.
Chubb, Harry Emory, Chorley Wood, Herts.
Dailey, Miss Dew, M.A., Parkersburg, Iowa, U.S.A.
Deacon, Henry, Blackpool, Lancashire.
Dean, Clayton Dewitt, Toronto, Ontario, Canada.
Dutt, L. B., Calcutta, India.
Edmiston, James E., Rancagua, Chili, S. America.
Egidius, Thorvald Fredrik, D.Sc., Utrecht, Holland.
England, Jack Culley, Purley, Surrey.
Eppel, B., Edinburgh.
Farley, Professor John Herbert, Appleton, Wisconsin, U.S.A.

Feist, Henry James Banes, Leigh-on-Sea, Essex.
Flower, Frederick William, A.S.A.A., London.
Flynn, George E., Bombay, India.
Fraser, Andrew, M.I.E.E., London.
Fraser, Horatio Nelson, M.D., Ph.M., Brooklyn, New York, U.S.A.

Gait, Sir Edward Albert, K.C.S.I., C.I.E., Camberley.
Geer, William C., Ph.D., Akron, Ohio, U.S.A.
Ghatak, Dhanapati, Calcutta, India.
Grant, Joseph Alexander, Montreal, Canada.
Gray, Alex., jun., Calcutta, India.

Haldeman, Cyrus B., Ross, Butler County, Ohio, U.S.A.
Hellen, Walter John, London.
Herring, Edgar John Cruickshank, A.M.I.E.E., Calcutta, India.
Hunter, George Leland, New York City, U.S.A.

Jackson, William, B.S, Pittsburg, Pa., U.S.A.
Jepson, Thomas Cecil, B.Sc., Toronto, Ontario, Canada.
Jodhpur, His Highness Maharaja Captain Sri Sir Umed Singh, Bahadur of, Jodhpur, Rajputana, India.
Jockel, Lauret Marshall, London.
Johari, R. K., Morar, Gwalior State, Central India.
Jones, John, Rugby.
Jones, Rowland, Bombay, India.
Kaul, C. N., Gantamanayakanur P.O., Madura District, S. India.
Khannah, P. P., Moradabad, U.P., India.
Khosla, Mansukh Rai, Delhi, India
Krishnaji, Rai, Benares City, India.
Kynoch, W. G., B.Sc, Montreal, Quebec, Canada.

Labanti, Edgardo Alfredo, Lucknow, India.
Lal, Rai Bahadur Chotay, O.B E. Moradabad, U.P., India.
Land, Leo Frederick, Ilford, Essex
Lapenta, Vincent Anthony, M.D. Indianopolis, Indiana, U.S A
Loosmore, William Charles, M.A., Sutton, Surrey.
Lucas, Oliver, Birmingham
Lulham, Peter Habberton, M.R.C.S., L R.C.P., Hurstpierpoint, Sussex.
McDowall, Charles H., Bombay, India.
MacDowell, Charles Henry, D Sc. Chicago, Illinois, U.S.A.
McKay, John Wallace, A.R C.Sc (I), Calcutta, India.
MacLean, George E., Ph.D, LL.D, London.
Madon, James, M.Inst.C.E., Calcutta, India.
Magnus, Laurie, M.A., London.
Mehra, Mutasuddi Lall, Delhi, India.
Mews, Herbert, Upper Portslade, Sussex.
Molle, Dr. Cav. Capno. Stefano, Rome, Italy.
Mukherjee, N. N., Calcutta, India.
Nagi, Jagatsingh B., Karachi, India.
Naidu, S. R. M., London.
Neate, Percy John, J.P., M.I.M.E., London.

Nehra, R. S., B.A., Uganda, Africa.
Newhall, Henry B., B.S., New York City, U.S.A.
Niven, William, Mexico.
Norfor, Frank Frederick, Buxton, Derbyshire.
Osbourne, Lloyd, London.

Pack, Charles, Elmhurst, L.I., U.S.A.
Pal, F., Calcutta, India.
Parija, Pran Krishna, B.Sc., B.A., Cuttack, Orissa, India.
Paterson, David, Cachar, India.
Prasad, Rai Sahib Madho, Delhi, India.

Rai, Amrit, M.A., Lahore, India.
Raju, S. Dhanakoti, Mem.Am.Soc.M.E., Madras, India.
Ricardo, Ralph, Bombay, India.
Ripley, Lieut.-Colonel Blair, C.B.E., D.S.O., M.Inst.C.E., M.Am.Soc.C.E., Toronto, Canada.
Riyaz, Chaudhery, Abdul Rahim, B.A., Amritsar, India.
Robertson, Harry Frederick, A.M.I.E.E., London.
Rorke, Captain Alexander, R.E., M.C., A.M.I.E.E., London.

Sawhney, Isher Das, M.A., LL.B., Abbottabad, N.W. Frontier Province, India.
Selemgeria, D. Govin, Naini Tal, U.P., India.
Siddle, George, F.C.S., Middleton St. George S.O., Co. Durham.
Singh, Raja Prithipal, F.R.G S., Oudh, India.
Singh, Sirdar Harnam, Amritsar, India.
Small, D. R. Murison, London.
Smith, Henry Lees, New York City, U.S.A.
Smith, William Nelson, M.E., Winnipeg, Manitoba, Canada.
Souter, Edward Matheson, Cawnpore, India.
Srivastava, B. P., Cawnpore, India.
Stanlaws, Penrhyn, Hollywood, California, U.S.A.
Steeves, Clarence McNaughton, B.A.I., M.Sc., M.Am.Soc.C.E., Fredericton, N.B., Canada.
Strauss, Joseph B., Chicago, Ill., U.S.A.

Taber, Edmund Rhett, jun, M.S., Alabama, U.S.A.
Thompson, Dr. A., M.A., D.D.S., Simla, India.
Tikamdas Nersian, Dharamdas, Karachi, India.
Ufer, Walter, New Mexico, U.S.A.
Underwood, Mrs. Edna Worthley, New York City, U.S.A.
Van Alstyne, Miss Eleanor v. N., Ph.D., M.D., New York City, U.S.A.
Vincent, Walter Karl Eduard, Toronto, Ontario, Canada.

Wade, Prof. Bruce, Ph.D., Tampico, Mexico.
Wagner, Colonel Frederick H., M.Am.Soc.M.E., Baltimore, Maryland, U.S.A.
Walker, James Ernest, Calcutta, India.
White, Colonel Owen Willmer, Gerrards Cross, Bucks.
Whitmore, J. Darlington, Whangarei, New Zealand.
Williams, Richard Thomas, Widnes.

Williamson, G. Miller, Leith, N.B.
Woods, Prof. James Haughton, Ph.D., Cambridge, Mass., U.S.A.

The Chairman's address will be published in the next number of the *Journal.*

ADMISSION TO MEETINGS.

Fellows have the right of attending the Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Fellow can admit two friends to the Ordinary and Sectional Meetings, and to the Cantor and other Lectures. Books of tickets for the purpose are supplied on application to the Secretary of the Society, but admission can also be obtained on the personal introduction of a Fellow. For the Juvenile Lectures special tickets are issued.

A SUCCESSFUL CRUSADE AGAINST FLIES AND CHILD MORTALITY.

By E. Halford Ross,

A Senior Medical Assessor at the Ministry of Pensions; Medical Officer to the Factories of the City of London under the Home Office; Medical Member of Council, Industrial Welfare Society. Lately of the Public Health Department, County of London; Research Scholar at the Lister Institute and at the Liverpool School of Tropical Medicine. One time Health Officer of the Suez Canal and Cairo. Medallist, Royal Society of Arts.

The aim of medical research is the prevention of disease. To obtain even a reduction of a disease investigated within a life-time, in a large community, is rare. Yet the reduction of one house-fly borne disease has occurred in England and Wales within a decade ; and a generation should see its prevention. The story is an interesting one.

A century ago several doctors suggested that maladies might be carried from one human being to another by mosquitoes ; but they produced no definite evidence. In 1878, Bancroft, Cobbold and Manson declared that human blood worms were mosquito-conveyed. It was after Manson's careful work on this subject that he produced his famous induction that such insects were the vectors of malaria—a theory which was proved a fact by my brother, Sir Ronald Ross, in India in 1897-9. I visited him there then, and saw the development of disease parasites within the bodies of mosquitoes.

In 1900, the Suez Canal Company began an experiment at Ismailia, a small town in the Canal zone, with the object of preventing malaria. By means of draining or oiling all stagnant water, mosquitoes were prevented from breeding, and by 1903 malaria was abolished and Ismailia made healthy. This successful experiment became famous, and it led to the ultimate cleaning of the Panama Canal zone as well, by the late General Gorgas in the early years of this century. In 1905, while a surgeon in the Royal Navy, I was appointed by the Egyptian Government to undertake similar measures at Port Said, and was for four years health officer there. The experiment at Ismailia was copied, Port Said was soon rid of its insect pest, and the death rate fell from 29 per 1,000 to 20 per 1,000. The town was converted from a "sink of iniquity" to a seaside health resort, and during the late war was used as a base for our troops and a position chosen for several general hospitals. The methods employed were imitated afterwards by Lord Allenby in his advance up the fever stricken Jordan valley, as described by him at the Mansion House in 1920. It was during that period at Port Said that the possibility of house-fly reduction, similar to the mosquito reduction then in progress, came under investigation. As mosquitoes disappeared, flies became more obvious. But little certain information was ready to hand concerning their breeding places and still less about their disease bearing propensities. In order to get rid of mosquitoes the local press in Egypt had been asked to help and had responded eagerly. But in the absence of knowledge regarding flies, one hesitated to ask again for a compaign against what is now known to be a source of high infant mortality.

In 1909, however, after transfer to Cairo an experience occurred which set aside all doubts as to the danger of house-flies. It was described by Sir John Bland-Sutton, at a meeting of the British Medical Association. "Dr Ross tells us that the spring of that year was ushered in by a heat-wave on May 1st, and the temperature rose to 102°F. in the shade. Fourteen days later the greatest plague of flies ever remembered appeared in the city. Food, milk and fruit were contaminated by them. In two months 3,000 children under five years of age succumbed to enteritis—a disease due to infection. It is not an unreasonable assumption that the death of the Egyptian infants, which induced Pharaoh to let the children of Israel go, was due to an epidemic of enteritis spread by an enormous swarm

of "divers sorts of flies." Cairo was a filthy town, in a grossly insanitary condition. The flies bred in myriads and the houses were soon swarming with the pest. The insect plague surpassed that of South Africa during the Boer War. It was followed rapidly by the death of the newly born, not merely that of the first born, as in the Biblical story. On all sides were the cries of Rachel weeping. The general death rate leapt up, and in one week it reached the appalling figure of 105 per 1,000. The hospitals, dispensaries, charities were worked at full pressure, but still the infants died. It was an experience never to be forgotten.

On returning to England in 1911, enquiry and research into flies and disease was begun first at the Liverpool School of Tropical Medicine, then at the Lister Institute of Preventive Medicine in London. At the former, the work of Howard, Hewitt, Nuttall, Austen, Graham-Smith, Tsuzaki, Ficker, Hamilton and Newstead was studied; these writers had shewn that flies breed in horse-manure and in stable and house-refuse. At the latter the then recent researches of Morgan and Ledingham had appeared; they had discovered a bacillus named *Morgan I.* in infants suffering from enteritis; had inoculated this bacillus into monkeys and produced a similar disease in them; and had found the same bacillus in and on flies caught in the houses of the infected children. No further proof of the implication of flies as transmitters of infantile enteritis was required. Koch's well-known postulates had been fulfilled, and the information wanting in Egypt was complete. It remained to apply the knowledge gained in order to reduce flies at home, to attack their breeding-places as those of mosquitoes had been attacked on the Suez Canal zone; and so reduce and perhaps prevent ultimately the fly-borne infant mortality. As at Port Said, an appeal was made to the Press.

The spring and summer of 1911 in England were unusually warm. May was fine and sunny, June was hot, July continued so. During the last week in July infants began to die of enteritis. Their death-rate rose from 173 to 304 per 1,000; a month later it had risen to 636 per 1,000. An article was written and published in *The Morning Post* on September 2nd entitled "Flies and the death of the Innocents," it pointed out that high temperatures cause fly-eggs to mature rapidly, and heat quickens the development of fly-grubs; whilst rain drowns many grubs feeding in exposed places. It was shewn that the heat wave and drought conspire together to produce house-flies, and house-flies kill children. And it was suggested that these insects should be attacked while in the larval, grub, or crawling stage by cleaning manure-heaps, stables, ash-bins, collections of refuse, and the regular clearing of anywhere and everywhere where flies could breed. It was emphasised that this should be done periodically throughout the country as it had been done in the Canal zones with the breeding-places of mosquitoes. "Let it be remembered that house-flies are a sign of insanitation and their numbers a measure of that insanitation." The matter was taken up by Mr. T. P. O'Connor, who demanded that "the eyes of the general public should be opened to what was really a grave danger at present fully unrealised." Among others he quoted a paragraph which has proved a prophecy: "There is, however, already an improvement. Flies are not nearly so numerous as formerly in London. This is due partly to sanitary science, but partly to petrol. The mews in the west end have become garages, and the cab-horse and hack are disappearing. Their 'bedding' is no longer there to harbour and feed fly-grubs; and in the better residential neighbourhoods only one fly pesters where before were dozens." Dr. Chalmers Mitchell, reviewing the work done at Port Said, in a middle article of *The Saturday Review*, said: "The diseases of the tropics make a dramatic appeal to us, and we are disposed to regard the familiar scourges of our own country as inevitable. But the extermination of the insect pests of our own houses is as important and as practicable as the campaign against mosquitoes and would lower the death-rate and increase the comfort and happiness of the population." It was little guessed then that ten years would turn the idea into an accomplished fact. Yet such is the case.

The following summer was wet and cold. Flies appeared in comparatively few numbers. But in the early spring of 1913, the suggestion was taken up again. Mr. Murray had prepared and published two books on the subject; Mr. Heinemann another. A review in *The Times Literary Supplement* was followed

by a leading article in the main issue. The prevention of house-flies rather than killing them was the main argument. *The Globe*, *Scotsman*, *Empire Review* continued it. *The Daily Express* repeated it with headlines. Then came *The Graphic* and *Daily Graphic*, with pictures of fly-grubs and chrysalides; *The Daily News*, *The Liverpool Post*, *Cardiff Mail*, *Liverpool Echo*, *Sheffield Telegraph*, *Manchester Courier*, *Birmingham Daily Post*, *The Field*, *Country Life*, the late Mr. G. R. Sims in *The Referee*, and *Punch* repeated the suggestion. *The Daily Mail* started an annual campaign.

Early in 1914, information came from New York of an experiment conducted in the borough of Bronx. A chosen district containing 1,725 individuals and 362 children under five years of age, was protected against house-flies by an organisation in which Boy Scouts and Inspectors were employed to deal with fly-grubs in the courtyards, waste-spaces, and stables. Another similar area was allowed to pursue its usual fly-plagued course. As a result there were only 110 cases of infant sickness recorded in the protected area, while among the "outside" families there was a total of 165 cases. This was the first practical attempt to prevent fly-borne disease, and so far as it went, was successful. Then the story of "House Flies and disease" was told before the Royal Society of Arts on March 18th, 1914, when a lively discussion followed. Mr. Carmichael Thomas was present, and he invited Mr. Harold Cox and the Press Association to take up the crusade again. It was in consequence of this that fly-reduction was converted into a propaganda, in which almost every newspaper in the country played a part. The effect was immediate. On April 6th, 123 medical officers of health memorialised the Local Government Board (Ministry of Health). They appealed to householders to cooperate with the health authorities in the effort to get rid of all breeding-places for flies, of all collections of refuse and garbage. It was published broadcast with numerous letters and interviews. On May 24th, a *cause célèbre*, which produced considerable stir, began in the Law Courts. Mr. J. O. P. Bland sued a neighbour at Sunbury for stacking manure in an adjoining garden, thus producing flies. Mr. Terrall, K.C., and Mr. Clauson, K.C., cross-examined experts for three days; and in his judgment for the plaintiff, Lord Justice Warrington decided that collections of horse-manure are sites of election for flies to breed, and as such are a public nuisance; he gave an injunction against the defendant. The case was reported widely, flies were denounced at the British Medical Association General Meeting at Aberdeen. The Local Government Board issued circulars, fly-prevention began to be taught in the schools. Infant Welfare Clinics paid special attention to fly-diseases; mothers were instructed to avoid fly-contamination of infants' food; posters and leaflets were distributed; the insects were filmed; and, finally, as such propaganda seems incomplete without its comic song, there appeared at the Vaudeville Theatre, "Where do the flies go in the winter time?" On several occasions various discussions arose concerning flies in which Mr. Gahan, of the British Museum (Natural History), the Vice-Chancellor of Cambridge, and Professor Howlett, of the Imperial College of Science, Lefroy of the Zoological Society, and others took part; these served to keep the subject constantly before the public.

There is no known method of accurately counting flying insects in any large locality; this was found a great difficulty in the areas of obvious mosquito and fever reduction; it is consequently quite impossible to measure the total number of flies in a whole country. But the numbers of horses, which are a chief source of flies, can be gauged; and the annual immigration of those birds which find in flies their prey, can be watched. Thus fly-reduction can be roughly estimated. In most of our towns, the cab-horse, bus-horse, tram-horse and riding-hack have gone, and they have taken their flies with them. Stables have been turned into garages, loose-box, "livery and bait" have disappeared, and the sites of election have become comparatively negligible in numbers. In the country the tractor is more slowly replacing the farm-horse, the delivery van is ousting the tradesman's cart. The Ministry of Agriculture states that there has been a reduction of 50,000 horses in agricultural holdings since 1911. And in allotments, gardens, farms and backyards, this propaganda has borne great fruit, for now only an occasional fly is seen where they before were swarming. This is confirmed by the decrease of swifts, swallows, and house-martins as noticed by "Bird Lover," Mr. Masefield, of Stafford, and A. C— B—, well-known naturalists.

The results of fly-reduction are most interesting. The Registrar General has very kindly supplied the following figures :—

ENGLAND AND WALES.

Deaths from enteritis among children under 5 years of age—

1901	1902	1903	1904	1905
35,103	16,656	21,582	33,922	24,040
1906	1907	1908	1909	1910
34,572	14,097	23,508	14,336	14,884

INTERNATIONAL LIST. A. B. C. D. E. F.

1911	1912	1913	1914	1915
40,470	8,478	22,431	19,500	16,310
1916	1917	1918	1919	1920
10,998	9,323	8,474	7,585	8,895

The year 1921 will be remembered as a record summer for warmth, drought and sunshine—ideal conditions for breeding flies; but the fly resurrection proved abortive, and 14,195 deaths occurred—one-third that of the former warm year of 1911.

Flies are greatly reduced in numbers throughout the country. During this past summer of 1922, I have toured England and Wales looking for house-flies, as I used to look for mosquitoes at Port Said. In those places where formerly they bred in myriads, there are only a few. In other places, where before there were thousands, they are conspicuous by their absence. Out of the way villages, and some farm houses still shelter the grubs and insects, but such places are comparatively few and far between. There is no doubt of fly-reduction. And in this summer, the figures shewing our infant mortality reduction are astonishing. The number of total deaths is not yet available, but the accurately estimated death rate is available and stands, during the warmest weeks, at 50 per 1,000. Compared with that of 636 per 1,000 during the warm weeks of 1911, it is an amazing record. It is reflected in the general death rate. This has fallen to its lowest—8.9 per 1,000. Compared with that of 105 per 1,000 at Cairo during the epidemic of infantile enteritis in 1910, it is a practical testimonial unsurpassed for our powers of propaganda in an educated people.

Dr. Hamer, Health Officer to the County of London, in his recent report, ascribes fly reduction to the advance of motor traffic. He is right; but his explanation is not the complete one. The deaths in 1920 were 8,895; in 1921 they numbered 14,195; yet there was more motor traffic in 1921 than in 1920, as the registration returns show. The medical correspondent of *The Times* ascribes fly reduction to the weather. He is right; but his explanation is not the complete one. The deaths in 1911 were 40,470; in 1921 they numbered 14,195; yet 1921 was a warmer, dryer, year. It is education, cleanliness, health, sanitation, propaganda, knowledge disseminated, science presented which has made the difference. Once more, though rarely, medical research has gained its aim. A disease investigated has been reduced in a large community within a decade. A life-time has seen it well started. A generation should see it prevented, and the life-waste of a great war replaced.

There are still deaths caused by flies among English children every year.

OBITUARY.

ARTHUR H. REID, F.R.I.B.A.—Mr. Arthur H. Reid died at Cape Town on October 18th. He went to South Africa in 1877 and was for a time in the municipal service there as a draughtsman and surveyor. Later on he became city engineer at Graham's Town, but retired from the public service in 1882. From then until 1887 he practised privately at Port Elizabeth, after which he left for the Rand goldfields, then recently discovered, where he was the first practising architect. Subsequently he returned to Cape Town, and practised in association with Mr. W. J. Delbridge.

Mr. Reid held a number of public offices: he was a member of the Cape Town City Council, and of the old Staats Raad of Johannesburg.

He was deeply interested in public health matters, and was instrumental in the training of Municipal inspectors for taking their diplomas in sanitary science. He was for a time President of the Association for the Prevention of Consumption and also President of the Cape Institute of Architects, and of the South African Institute of Real Estate valuers.

He joined the Society in 1899, was for some time a member of the Colonial Section Committee and he spoke in the discussion on Mr. Richard Jebb's valuable paper, "Imperial Problems of Asiatic Immigration," read on April 7th, 1908.

NOTES ON BOOKS.

THE PRACTICAL APPLICATION OF X-RAYS. By G. W. C. Kaye, O.B.E., M.A., D.Sc., A.R.C.Sc., F.Inst.P. London: Chapman & Hall, Ltd. 10*s*. 6*d*. net.

This volume is based to a large extent on the admirable course of Cantor Lectures delivered before the Society by the author in 1921.

The introductory chapter deals with the nature of X-rays, their generation, and the methods of detecting them. This is followed by chapters on the X-ray bulb, the high potential generator, and the measurement of X-rays. Chapter V. describes the medical applications of X-rays. This is a subject with which most redaers will have some familiarity, although they may not know to what an extent the rays are now used, not only in ordinary medicine, but also in veterinary science; the author shows, for instance, a photograph of the X-raying of an elephant which has swallowed a ring.

To many readers the last chapter, relating to the industrial applications of rays, will present the greatest novelty. Defects in materials and workmanship are discovered in this way with wonderful ease. A flaw in a weld, for instance, is detected at once, although hidden inches below the surface. During the war much use was made of X-rays in examining the structure of aeroplanes; knots, large resin pockets, defective glueing and poor workmanship are shown up at once by this method, and it is also used for watching the behaviour of the various hidden members, splices and joints of a composite wooden structure whilst it is being subjected to tests.

Another interesting application of X-rays is their use in connexion with pictures. The author quotes various cases in which works by old masters, which have been painted over by later artists, have been detected and brought to light again; while the authenticity of several well-known works of Rembrandt, alleged by some critics to be spurious, has been established beyond a doubt.

ARGHAN: A NEW TEXTILE MATERIAL.

An interesting article is contributed to the *Textile Recorder* by Mr. Alfred S. Moore, on the newly developed textile material known as Arghan. The fibre owes its discovery not to anyone connected directly with textiles. When Sir Henry Wickham, the pioneer of the plantation rubber industry, was exploring South America in search of further supplies of that valuable commodity, he came haphazard upon the arghan in its natural plant habitat. True, the natives were utilising it for harness, belts, bags and other purposes, but their preparation was wasteful, and only in very limited quantities for their own domestic and other purposes.

As a plant it seems to belong to the Maguey or pineapple description, and though he collected specimens, their application did not occur to him until later. Our foreign dependence upon hemp was troubling Mr. Henry Wilson, managing director of the Belfast Ropework Co., Ltd.—the world's greatest rope and twine making concern—and arghan was submitted to him as a possible substitute. At once he discerned its potentialities in that line. It could be spun into twine absolutely indurate to sea water ravages, and so strong that the twist given by the shop assistant when he had completed tying up his parcel was impossible to break it. In fact, it seemed too good to use merely as twine.

Arghan was then passed into the hands of spinning experts, and they further confirmed Mr. Wilson's opinions. It was found to be fully 50 per cent. more tensile than best hemp or flax. Could it be woven into cloth? Only some minor loom adjustments were necessary, and the result was a magnificent firm cloth. In fact, it has been spun to 25 lea, and cloth has been woven from yarn of this number with great success.

But the problem was how to ensure ample supplies. Even apart from the crude, petty preparation and collection by the South American natives, the transport difficulties would have been nigh impossible.

Moreover, it was desired that the commercial development of arghan should be on all-British lines. With that object then, an expedition was despatched to the South American wilds in winter, 1918, and a goodly supply of roots and suckers was transported to the Federated Malay States, where a nursery had been established. Indeed, the F.M.S. Government were so satisfied that they forthwith placed at the disposal of the Arghan promoters a tract of 30,000 acres, without any premium rent being exacted. And here the plants are in wholesale cultivation. In addition, too, the Indian and Ceylon Governments have set apart similar great areas for its cultivation.

Messsrs. Bevan and Cross, the F. M. S. fibre experts, declared arghan unsurpassed in merits by any other fibre submitted to them. As a matter of fact its success has not belied one whit the declaration of Mr. Abraham Montefiore, chairman of the Arghan parent company, who said that the more renowned the expert who had examined the arghan the more enthusiastic was his verdict.

Placed before Lancashire textile manufacturers they proved that it also bleached well, in addition to taking and retaining dye. Especially were the twine and rope making section gratified. So much so that they averred that they, as a body, would take all arghan offered for the making of nets, belting and other cordage. A leading British bleacher goes so far as to prophesy that if only this fibre can be produced at a lower cost than similar flaxen or hemp fabrics it must rival them in use.

One great virtue is that there is no need for the tedious preparation essential in hemp, flax and ramie. The leaves simply split up into long, silky fibres, up to seven feet long, of pearly white colour.

The advent of arghan comes at an opportune moment to give heart to manufacturers troubled

over future flax supplies. Further, no obstacle is put in the way of manufacturers desiring supplies, since Lancashire and Scotch subsidiary companies have been formed to ration these. So far it seems destined to play a great part in replacing cotton for all heavy classes of canvases.

THE AUSTRIAN FILM INDUSTRY.

The Austrian film industry has developed rapidly during the last five years. Owing to favourable geographical position and other conditions essential to the production of films, such as scenery, architecture, and interiors, Vienna has become the centre of this industry for Austria and the States of Succession, as well as the shipping point for the Balkans and the Orient.

In Austria, writes the United States Consul at Vienna, there are about 15 factories producing long and medium length films, six copying establishments, and eight studios with photo rooms, etc. These all are well equipped. Production is steadily increasing, and at present is about 100 middle-length films annually. One-fourth of these are exported. The cost of producing a film of middle length amounts to approximately 25,000,000 Austrian crowns, or nearly £400 at the current rate of exchange.

The requirement of Austria and the States Succession is from 700 to 800 films a year. This demand is met chiefly by imports. In 1921, 55 per cent. of the imports came from Germany, 20 per cent. from the United States, and 25 per cent. from France, Italy, Sweden and Norway.

There are more than 400 cinemas in Austria and 200 in Vienna.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 20..Actuaries, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. L. M. Tye, "Illuminating Engineering in relation to Architecture."

Brewers, Institute of, at the Institute of Chemistry, 30, Russell Square, W.C. 8 p.m. Mr. W. A. Riley, "Elimination of Waste."

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W., 7.45 p.m. Annual General Meeting, 8 p.m. (1) Prof. T. M. Lowry, "Intramolecular Ionisation." (2) Mr. C. J. Smith, "On the Viscosity and Molecular Dimensions of Hydrogen Selenide." (3) Mr. W. R. G. Atkins, "The Hydrogen-ion concentration of Natural Waters and Etching Reagents in relation to Action on Metals." (4) Mr. E. W. J. Mardles, (a) "The Scattering of Light by Organosols and Gels of Cellulose Acetate." (b) "Studies of the reversible sol to get transitions in non-aqueous Systems."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Section.) Mr. H. R. Hockley, "Works Management."

TUESDAY, NOVEMBER 21..Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m.

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Geographical Society and Alpine Club (Joint Meeting), Central Hall, Westminster, S.W., 8.30 p.m. First Exhibition of the Mount Everest Expedition Cinematograph Films taken by Capt. J. B. Noel.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Miss M. A. Murray, "Recent Excavations in Malta."

Transport, Institute of (Graduates' Section), at the Institution of Electrical Engineers, Victoria Embankment, W.C. Mr. W. H. Gaunt, "The Distribution Organisation of a large Departmental Store."

Chadwick Public Lecture, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 5.15 p.m Miss A. D. Muncaster, "Some Hygienic Aspects of Food and Food Preparation."

WEDNESDAY, NOVEMBER 22..United Service Institution, Whitehall, S.W., 3 p.m. Brig.-General W. R. Ludlow, "National Cadets."

St. Paul's Ecclesiological Society, St. Andrew's Court House, 7, St Andrew's Street, Holborn, E.C., 8 p.m. Mr. E. W. Harvey Piper, "Gloucester Cathedral."

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m. Mr. E. Fagg, "The Naturalistic Motive in Modern Pictures."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. F. S. Button, "Industrial Co-operation: Works, District, National."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. H. Scurfield, "The Milk Problem, including the use of Dried Milks."

University of London, University College, Gower Street, W.C., 6.15 p.m. Mr. A. W. Flux, "Foreign Exchanges." Lecture III. "Purchasing Power, Parities in Theory and Practice."

Meteorological Society, 49, Cromwell Road, S.W., 5 p.m. (1) Sir Napier Shaw, "Account of the work of the Meteorological Section of the International Union of Geodesy and Geophysics during the meeting at Rome in May, 1922." (2) Mr. A. H. R. Goldie, "Circumstances determining the Distribution of Temperature in the Upper Air under conditions of High and Low Barometric Pressure." (3) Rev. José Algué, "The Manila Typhoon of May 23rd, 1922."

THURSDAY, NOVEMBER 23..Royal Society, Burlington House, Piccadilly, W., 4 p.m.

British Decorators, Institute of, Painters' Hall Little Trinity Lane E.C., 7.30 p.m. Mr. W. J. Pearce, "How, When and Where come Colour and Ornament."

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Historical Society, 22, Russell Square, W.C., 5 p.m. Rev. Prof. J. P. Whitney, "Sir George Prothero—Historian and Teacher."

Camera Club, 17, John Street, Adelphi, W.C., 8.15 p.m. Dr. G. H. Rodman, "The Story of the Cuckoo Spit."

Mechanical Engineers, Institution of (South Wales Branch), 102, St. Mary Street, Cardiff, 6 p.m. Mr. D. Wilson, "Boiler Efficiency under Test and Working Conditions."

Mining and Metallurgy, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

University of London, at the London School of Economics and Political Science, Houghton Street, W.C., 6 p.m. Sir Frederick Lugard, "Economic and Administrative Problems of the British Tropics." (Lecture I.)

FRIDAY, NOVEMBER 24..University of London, University College, Gower Street, W.C., 5.15 p.m. Mr. C. T. Regan, "Problems of Evolution, with special reference to Fishes." (Lecture III.)

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Adjourned Discussion on Mr. Reavill's paper, "Air Compressors."

Physical Society, Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the meeting.

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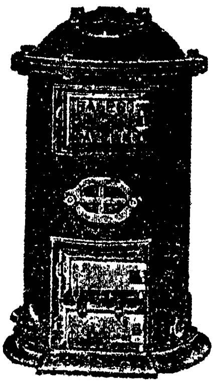

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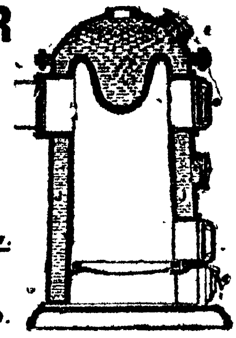

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